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COTTONSEED PROCESSING CLINIC

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February 8 and 9, 1965

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UNITED STATES DEPARTMENT OF AGRICULTURE

FOREWORD

The USDA's Agricultural Research Service wants to assure that the Nation will receive maximum benefit from its research programs. Utilization research is constantly developing new ideas and products which show great possibilities of benefiting growers, industry, and consumers.

The Cottonseed Processing Clinic is sponsored annually by the Southern Utilization Research and Development Division in cooperation with the Mississippi Valley Oilseed Processors Association, Inc. Its purpose is to acquaint representatives of the cottonseed industry with current developments in utilization research and to provide for an exchange of information that will benefit future research.

These proceedings report the statements presented by the various speakers during the 1965 Clinic and give an account of the discussions during the three panels.

C. H. Fisher
Director, Southern Utilization Research and Development Division

GENERAL CHAIRMAN
Robert F. Patterson

CO-CHAIRMEN
Bruno H. Wojcik
Laurence W. Mazzeno, Jr.

CONFERENCE COORDINATOR
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WELCOME

by

C. H. Fisher
Southern Utilization Research and Development Division

Mr. Chairman and Members of the Conference:

It is again my privilege--and one that I enjoy and appreciate--to say "welcome" at the opening of a Cottonseed Processing Clinic. We in the Southern Utilization Research and Development Division (SURDD) are pleased and proud to cooperate with the Mississippi Valley Oilseed Processors' Association in sponsoring these annual Clinics, which bring together leaders from industry and from various units of the U.S. Department of Agriculture, including Federal Extension Service, Economic Research Service, and the Agricultural Research Service.

Our Chairmen, R. F. Patterson, B. H. Wojcik, and L. W. Mazzeno, Jr., and our Program Committee, composed of W. K. Martak, C. E. Garner, L. A. Goldblatt, and H. L. E. Vix, have arranged what promises to be an excellent meeting. The program includes some important topics to be discussed by authorities from the United States and Central America, and I am sure that this will be another useful and successful Processing Clinic.

There have been several significant happenings in the overall research situation during the past year.

The Federal Government, which supports about 75 percent of the Nation's research, has adopted a new policy toward research, for the coming year at least. Of late, the Federal budget for research and development has grown rapidly, from $9.2 billion in fiscal year 1961 to about $15.3 billion in fiscal year 1966. The latest budget calls for another increase in research and development, but the rise will be the smallest in a decade. At least two trends are apparent in the overall research situation. Future rates of increase will be smaller, and some types of research will be favored over others.

As you may know, Secretary Orville L. Freeman has announced a restructuring of USDA research that will close several small stations and eliminate some lines of work completely. Savings of more than $5 million are expected to result from these curtailments in FY 1966. The programs on cotton and cottonseed, however, will not be reduced by the restructuring plan.

With regard to cottonseed research, I am proud to be able to say that SURDD scientists--working in cooperation with other organizations--have made excellent progress.

For example, only a short time ago there was much concern about the cyclopropenoid materials in cottonseed. Because of rapid and important progress in research, concern about these materials is much less today. Sensitive and reliable test methods have been developed. We now have a much better understanding of the chemistry and properties of the cyclopropenoids. Also, simple and inexpensive inactivation methods are now available.

Aflatoxins represent another important area of cooperative research. Although this work is relatively new, progress has been rapid and substantial. Dr. Goldblatt will give you more details about these accomplishments.

Mr. Feuge will describe a method, attractive in its simplicity, for preparing confectioners' fat from cottonseed oil. We anticipate that this method will be adopted commercially to make a substitute for cocoa butter.

Other speakers will tell how the mixed solvent process can be used to prepare a highly nutritious cottonseed flour at reasonable cost.

Our work on cottonseed flour is supported by AID, the Agency for International Development. The principal purpose is to develop improved flours for human consumption. The results, however, should be useful in making better feeds from cottonseed.

Cooperative work on cotton batting continues to make gratifying progress. W. G. Van Saun was scheduled to give you the details in his talk. In the absence of Mr. Van Saun, W. G. Davis will present his paper.

It is not necessary to remind this audience that the fate of cottonseed is closely related to that of cotton lint.

SURDD scientists and engineers are constantly making important contributions to the advancement of the cotton textile industry. Stretch cotton products, based primarily on findings of this Division, have been highly successful. Wash-wear fabrics, flame-resistant fabrics, and other cotton products are being improved constantly through research. All this is good for cottonseed, as well as for cotton, and is of great benefit to the consuming public.

Turning briefly from research to administrative matters, there have been 3 important personnel changes in USDA which may be of interest to you.

More than a year ago, Dr. Nyle C. Brady was appointed to the newly created position of Director of Research and Education for the entire U.S. Department of Agriculture.

Dr. G. W. Irving, Jr., has been promoted from Deputy Administrator of the Agricultural Research Servide to Associate Administrator.

The vacancy created by Dr. Irving's promotion was filled by appointing Dr. Fred R. Senti to the position of Deputy Administrator. Dr. Senti, who now administers all USDA utilization and consumer use research, was Director of the Northern Utilization Research and Development Division in Peoria prior to his promotion.

These 3 men are recognized as being excellent scientists, competent administrators, effective leaders and dedicated public servants, and can be depended upon to carry out their duties in a manner consistent with the high standards of the Department.

In conclusion I wish to thank everyone contributing to our Cottonseed Processing Clinic. In particular, I wish to express my appreciation to the Chairman, the Program Committee, to those presiding at the various sessions, and to Dr. Wojcik and coworkers for their efforts.

Again, we are glad you are here, and hope that you will find this conference worthwhile.

OPENING REMARKS

by
W. K. Martak
President
Mississippi Valley Oilseed Processors' Association, Inc.

We express our thanks to you, Dr. Fisher, for such a warm welcome. We further express our thanks to you, as well as your entire staff, for the many favors and especially the way that all of you have made us feel--"at home."

We have worked very close in the past in solving our problems, and it is imperative that we work closer in the future.

Recently there have been a number of publications about what will happen in the next 15 years. In reviewing these predictions, we can place our faith in the future.

1. Our population now is 192 million, 15 yr. from now it will be in the neighborhood of 250 million--up 30 percent.

2. Families will increase by some 50 percent over the present number of 55 million.

3. Gross national product will go up some 50 percent or more (it is now 640 billion). All of this means we will have a greater potential market for our products. Consumption of cottonseed oil should rise in relationship to the population increase, as well as consumption of linters, meal, and hulls, for all predictions point to higher productions to supply the increased population.

Now turn the page to our industry. In 1950, there were 331 cottonseed oil mills. Today there are around 180, or a decrease of 46 percent in the past 15 yr. These 180 oil mills crush the seed from about the same size cotton crop as the early fifties. Therefore, all cottonseed oil mills need to operate in a more efficient manner each year.

So, all of you can see from these figures and predictions we need to continue our close relationship to maintain and improve our efficiency, and also endeavor to find new markets. The Southern Utilization Research Laboratory is one of our very important sources of information for both current and future problems. We want all of our friends at the Laboratory to know that we recognize and appreciate the

work that they have done, and are doing, for us.

We are sure that you have examined your program several times, and are looking forward to an interesting and informative program. We realize that Dr. Fisher and all our friends at the Laboratory have put a lot of thought and hard work into the planning of our 1965 Clinic. We want each one of them to know that we greatly appreciate their efforts in our behalf. Therefore, from all of us, Dr. Fisher, to all of you at the Laboratory, we say "thank you."

FIRST SESSION

L. W. Mazzeno, Jr., Chairman

THE MYCOTOXIN PROBLEM

by
Leo A. Goldblatt
Southern Utilization Research and Development Division

Abstract

Molds in feeds have been a problem for a great many years. The developments in 1960 relative to the "Turkey X" disease in poultry dramatized and focused attention on the problem of mold toxins and gave impetus to mold toxin research.

The Southern Regional Laboratory is conducting one part of a comprehensive Department program of research on mycotoxins that embraces many agricultural commodities. Its broad objectives are: (1) To develop analytical methodology, (2) to determine the effect of graded levels of aflatoxin on various experimental animals, including farm animals, (3) to find practical methods for preventing or at least minimizing mold growth in our commodities, and (4) to develop processes for removing or destroying toxins in those lots of our commodities that may have been contaminated with toxin producing molds. Some of the results obtained from this work will be presented. Excellent liaison has been established and is being maintained by the Department with affected industry groups, such as the research committees of the National Peanut Council and the National Cottonseed Products Association (NCPA), and with the Food and Drug Administration.

The presence of mold toxins is potentially the most serious quality problem which faces the producers, manufacturers, and handlers of food and feed products. It could become a problem for all agricultural commodities--not just cottonseed and peanuts. The problem is an important one, but it is getting much research attention.

My assigned topic today is the mycotoxin problem, potentially the most serious quality problem that faces the producers, manufacturers, and handlers of food and feed products. There has been scarcely a day in the past year that we have not talked about mycotoxins in our laboratory. But it may well be Greek to you, as it was to all of us only a few years ago. You will not even find the word mycotoxin in the dictionary; at least I did not find it in the latest unabridged Webster--that's the 1961 edition printed in 1964. I did find the word myco, which is defined as "a combining form from the Greek Mykes, meaning fungus." A mycotoxin, then, is a toxin, a poisonous material, produced by a fungus--which is another way of saying that a mycotoxin is a poisonous material produced by a mold. A mycotoxin is not itself a mold; it it a toxic material produced by a mold. The mold itself is a living organism; the mycotoxin is an inanimate thing. A mycotoxin is not living; it is a specific chemical or a mixture of chemicals. A specific mycotoxin is produced by a mold but it is not the mold itself and you cannot make a mold out of it. So much for definitions.

Molds are ubiquitous and they have been around for thousands of years. Professor Clyde Christensen of the University of Minnesota has pointed out (2) that many of the molds are so abundant and so prevalent that they must be considered one of the more successful forms of life. Of the 2 million different kinds of living things on our earth, molds make up about 100,000 species.

Molds affect us in many different ways. Most of us think of all molds as being harmful but nothing could be further from the truth.

Of these 100,000 different kinds of fungi, only 2 or 3 dozen species are known to produce disease in man; on the other hand, molds are the chief cause of diseases in plants. They can also cause heavy loss in stored seeds of all kinds and can cause decay in manufactured products such as lumber, cloth, leather, electrical insulation, and in food products, too. But, without molds, we would not have Roquefort cheese, or soya sauce, or penicillin and other antibiotics. Penicillin is a mycotoxin for bacteria and lower forms of life but not for man and most higher forms of life.[1/] But just as some molds can produce penicillin and other antibiotics that are toxic to lower forms of life, other molds can produce other chemicals that are toxic to higher forms of life including rats, poultry, farm animals, fish, monkeys, and even man himself. It is this special group of chemicals produced by molds, the mycotoxins, that is the subject for discussion today, particularly as they relate to your industry.

This is not a new problem, although it may have a new name, and it is not unique to the cottonseed industry. Molds in feeds have been a problem for a great many years. The list of reported cases of deaths or ill effects resulting from consumption of moldy feeds is a very long one. Animals poisoned include cattle, horses, pigs, guinea pigs, rats, rabbits, sheep, mice, and poultry. Materials implicated include various cereal grains, corn, sweet clover, dried grass, peanuts, cottonseed, rice, and other agricultural products. Comprehensive reviews of poisoning of animals by mold toxins were recently published by Forgacs and coworkers (6, 7).

But these isolated instances did not attract much attention even among specialists. Then 5 years ago the situation changed quite abruptly as a result of a major outbreak of poisoning in farm stock in England in 1960. During just a few months an estimated 100,000 young turkeys died from mysterious disease that was dubbed "Turkey X" disease. The difficulty was not limited to turkeys. On one farm alone 14,000 ducklings died (12) and on another some 5,000 partridge and pheasant poults died. Difficulties were also experienced with other farm animals, such as calves and swine. The troubles were traced quickly to an imported Brazilian peanut meal, and legal suits for more than a million dollars resulted (12). These spectacular reports of thousands of mortalities dramatized, or focused attention, on the problem and stimulated a great deal of activity, not just in the law courts, but also among scientists all over the world. Within about a year the cause of the mysterious "Turkey X" disease was traced to a toxic material produced by the very common mold known as Aspergillus flavus. The toxic material was christened aflatoxin for A. flavus toxin. These dramatic developments gave a tremendous impetus to research on mold toxins, or mycotoxins.

Because of our special interest in aflatoxin, our discussion today will be devoted mainly to aflatoxin, rather than to mycotoxins in general. However, it should not be forgotten that other fungi are known to produce toxic substances. There are other mycotoxins; they just have not gotten the attention that aflatoxin has. A partial list of more than a dozen toxins of molds, the food infected, and the symptoms produced in animals can be found in a very recent review by Friedman (9). To complicate things a little more it should be noted that the mold A. flavus produces toxic materials other than aflatoxin (14) and that aflatoxin is produced by molds other than A. flavus (3, 10). It has been suggested that today we may be on the threshold of a vast development with the mycotoxin problem comparable to that with vitamins half a century age. It was first recognized 50 to 60 years ago that certain diseases--for example scurvy and rickets--were caused by the absence of previously unrecognized trace nutrients now called vitamins. Today, we may be on the verge of discovering that certain diseases are caused by the presence of trace amounts of previously unrecognized mycotoxins.

But to get back to aflatoxin. It was soon found that under favorable growth conditions the mold A. flavus produces at least four very similar toxic substances and these were named aflatoxin B_1 and B_2 and aflatoxin G_1 and G_2. The letters B and G were assigned because the pure substances fluoresce blue or green when they are exposed to ultraviolet light. The B materials are those that fluoresce Blue; the G materials are those that fluoresce Green. The subscript 1 designates the substance that moves faster in solution under a particular set of chromatographic

1/ Penicillin causes allergic reactions in some individuals and high doses could result in fatal anaphylactic shock.

conditions that causes them all to flow. The subscript 2 then designates the slower moving components.

Thus, we now have four recognized aflatoxins. Each is a single, individual chemical compound. B_1 and B_2 both fluoresce blue when illuminated with ultraviolet light and B_1 is the faster moving of the two; G_1 and G_2 both fluoresce green and again the G_1 is the faster moving component. All four chemical compounds have been isolated in pure form, and their chemical composition and precise molecular structures have been determined. The structure of two of the aflatoxins, B_1 and G_1 is shown in figure 1. The

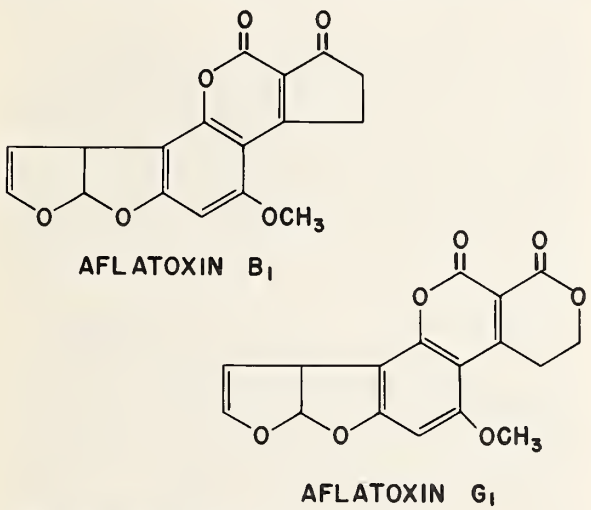

Figure 1.--Structure of aflatoxin B_1 and aflatoxin G_1

aflatoxins are produced by a living organism, especially certain strains of the mold known as Aspergillus flavus, but they are not themselves living things. From our knowledge of their structures and our knowledge of the behavior of chemical compounds of related structure we can infer a good deal about the chemical behavior of these four compounds. At least a dozen strains of the mold A. flavus have been reported by various investigators to produce aflatoxin but the amount and proportion of the four aflatoxins produced appear to be highly variable. In addition, the mold A. parasiticus has been reported to produce relatively large amounts of aflatoxin when cultured on peanuts in the laboratory (3). Also, an altogether different mold, Penicillium puberulum, has been reported to produce all four known aflatoxins when cultured on shredded wheat (10).

The four aflatoxins are found in plant products only in very small proportions--amounts that are generally reckoned in parts per billion. But that is enough. These are extremely potent toxins and they may produce liver cancer in some animals. The toxicity varies greatly with different animals. One of the most sensitive is the young duckling, which is generally used as the test animal for assay. About 20 to 30 μg. of aflatoxin B_1 will kill a 1-day-old duckling. About 3 or 4 times as much of G_1 and about 10 times as much of B_2 and G_2 is required to do the same job. But 20 to 30 μg. is an extremely small amount. The potency might be visualized in this way: 1 oz. of aflatoxin B_1 could kill a million ducklings. A package of cigarettes weighs just about 1 oz. Literally, 1 oz. of aflatoxin B_1, the weight of a single package of cigarettes, properly distributed, could kill a million ducklings.

So far we have been talking about things that happened in England. You will recall that the "Turkey X" disease developed in England in 1960. It was 1961 before it was recognized that the disease was due to toxins produced by molds. For a while we in the Unites States rocked along with the notion that the contamination was due to poor technology in underdeveloped countries and that our technology is more advanced--we had an "it can't happen here" attitude. But we were due for a rude shock. As said earlier, the problem of molds in feeds is not a new one. It is just that previous outbreaks have not been so spectacular. Interestingly enough when the British recognized the cause of the difficulty they called attention to earlier work in the Southeastern United States on diseases from moldy diets. Back in 1957 Burnside and others reported that a disease of swine and cattle in Georgia had been caused by eating moldy corn (1).

Nevertheless, the possible presence of aflatoxins in agricultural commodities in the United States was first reported in 1963. In April 1963 a research group in California reported that a specific feed had produced a high incidence of hepatomas (liver cancer) in hatchery trout and that cottonseed meal was implicated. As a consequence, the California State Department of Health announced in May 1963 that cottonseed meal was being eliminated as an ingredient of dry fish food in all California hatcheries. From the data subsequently published by the California group (15), it appears that although the diet containing cottonseed meal produced the highest incidence of hepatoma, other feed ingredients were not always blameless. So,

although aflatoxin can be produced on many agricultural commodities if the conditions are favorable, the basic suitability of cottonseed meal for food or feed use has nevertheless been questioned. Unfortunately, the particular cottonseed meal that was used in the California experiment was not analyzed for aflatoxin and is not available for examination. We may never know what caused the trout hepatomas in the California experiment, but it appears very likely that aflatoxin was the causative agent. We now know that trout are extremely susceptible to aflatoxin and are perhaps the most susceptible animal species. Preliminary experiments have shown that a very few parts per billion of pure aflatoxin B_1 in the diet produce a high incidence of hepatoma in trout and that hepatoma may be produced when the aflatoxin content is as low as one part per billion in the diet. This would make aflatoxin the most potent carcinogen known.

At almost the same time, in the spring of 1963, Professor Salmon of Auburn University reported to the American Institute of Nutrition Section of the Federation of American Societies for Experimental Biology at their meeting in Atlantic City, that a domestic peanut meal, when fed to rats, produced a high incidence of hepatomas. Again, the presence of aflatoxin was a distinct possibility. So here we were, bombed almost simultaneously from both coasts--California and New Jersey--on two of our most important commodities, cottonseed and peanuts. We found that "it had happened here," and we got to work.

We began work at the Southern Utilization Research and Development Division in New Orleans in the late spring of 1963 with one microbiologist to see if we could detect on cottonseed or cottonseed products any aflatoxin or any of the mold (Aspergillus flavus) that produces aflatoxin. Since then our research effort has increased to a level of 10 professionals working on the problem in New Orleans and research contracts have been negotiated at Auburn and at Texas A&M University. Plans for additional research in foreign countries with Public Law 480 funds are under active consideration. The Department's research effort on molds and mold toxins has expanded so that now nine research divisions[2/] of the Agricultural Research Service and eight State Agricultural Experiment Stations[3/] are involved. Many agricultural commodities are being studied. The Department is spending more than a million dollars a year on a broad program of research relating to all agricultural commodities on which molds can occur.

There is not enough time to tell you all about the Department's program or even about everything we have done in New Orleans, but it might be feasible to give you some of the highlights of our work there. Rather early in our work on aflatoxin we felt the need of a thorough review of the relevant literature. We made such a review and as a byproduct we prepared a "Bibliography on Aflatoxin from 1960." That had some 188 references and covered all the literature through 1963 fairly thoroughly. We planned to revise the bibliography from time to time and the first revision[4/] has just been completed. This revision provides fairly complete coverage to January 1, 1965, and has more than 400 references.

Although our very first experimental work in this program involved cottonseed, we considered aflatoxin in peanuts to be the more immediately critical problem. In 1 phase of our work on peanuts we conducted a survey of the incidence of aflatoxin in peanut stocks held by the CCC throughout the country, something like 200,000 tons of peanuts. This survey was doubtless an important factor in developing the Department's contract program for the marketing of the 1964 peanut crop. That program was designed to assure that only high quality peanuts are marketed for food and those not meeting these standards are channeled into nonfood uses. A four-phase program for peanuts was announced in July 1964: (a) Changes in the price support program; (b) educational assistance to the peanut industry to help improve the quality of peanuts through improved methods of growing, harvesting, drying, storing, shelling, and processing; (c) Federal-State inspection of all lots of shelled peanuts; and (d) a research program seeking better ways to eliminate damage to peanuts, particularly damage due to molds. An important feature of this new

2/ These are: Agricultural Engineering; Animal Disease and Parasite; Animal Husbandry; Crops; Market Quality; Transportation and Facilities; and Northern Utilization, Southern Utilization, and Western Utilization.

3/ These include Virginia, Georgia, Oklahoma, Texas, Iowa, Nortb Carolina, Alabama, and California.

4/ Skau, D. B., "Bioliography on Aflatoxin from 1960." U.S. Dept. Agr., Agr. Res. Service, Sou. Util. Res. and Dev., 40 pp (1965).

price support program is an insurance provision designed to eliminate or minimize any possible losses to peanut producers, shellers, or processors. The program is working out remarkably well. The National Peanut Council adopted a Voluntary Code of Good Practices for purchasing, handling, storing, and processing of peanuts. An excellent working relationship has been established between the Department, the peanut industry, and the Food and Drug Administration. This has been cited as an outstanding example of cooperation between industry and government. It may well serve as a model for future cooperation among the Department, the Food and Drug Administration, and other commodity groups.

In addition to providing information needed to develop the marketing program for the 1964 peanut crop, the survey resulted in several other important findings. One is that there are aflatoxin-producing strains of the mold Aspergillus flavus in all the important peanut producing areas of the United States. None is free, all areas are involved. I should hasten to add that while all the samples of peanut pickouts that were examined contained aflatoxin, relatively few of the samples of number one peanuts had any detectable amounts of aflatoxin and those that did had relatively low levels of aflatoxin. When contamination occurs, it appears to be highly selective. That is, a few kernels carry very large amounts of aflatoxin and the vast majority contain no detectable amounts.

This extreme selectivity has been confirmed more recently and will be discussed in more detail later. But that leads to another area of our work, which might be called analytical methodology. We have developed methods for analysis of cottonseed and peanut products that can be used routinely and, we understand, are being used routinely by some laboratories. We believe that they are superior to previously published methods. They are faster, more accurate, and more sensitive than those available as recently as a year ago. For example, the procedure we used for the peanut survey required about 2-1/2 days to complete one analysis. That doesn't mean it took 2-1/2 man-days for an analysis but the elapsed time from the beginning to the end of one analysis was 2-1/2 days. Now the elapsed time is down to about 4 hours, and we think the procedure is not only simpler to carry out but also more accurate and more sensitive. Our test is now sensitive to 2 to 4 p. p. b. of aflatoxin, but Professor Friedman of MIT has stated (9) that we should increase the sensitivity of our assays for aflatoxin to a fraction of a part per billion. He has mentioned a figure of 0. 01 p. p. b.

As part of our program on methodology we have prepared a working standard of a solution that contains known amounts of all four recognized aflatoxins. We are supplying a portion to any laboratory that needs a working standard. We put up this working standard in sealed ampoules and have now supplied about 200 of the ampoules to more than 100 different laboratories. This appears to have satisfied an urgent need, and we hope it will reduce the confusion that now exists in reporting the aflatoxin content of different materials by different laboratories.

In another phase of our work on analytical methodology we have developed micro or semi-micro methods so that we can analyze single peanut kernels or even a small part of a single kernel for aflatoxin. We needed such a method to spot contaminated kernels, and to differentiate individual kernels by degrees of contamination with aflatoxin.

In figure 2 are shown four peanut kernels that were "suspect" by reason of a rather unusual wrinkled appearance. One of these, number 16, was found to contain 20, 000 p. p. b. of aflatoxin. None of the other three contained any detectable amount of aflatoxin. As previously noted, the limit of sensitivity of our test is 2 to 4 p. p. b. That means that if the kernels contain any aflatoxin at all it is certainly less than about 4 p. p. b. and probably less than 2. In figure 3 is shown half a peanut kernel that looked perfectly all right from the outside but had a large amount of black material visible on the inside. The other half of this kernel analyzed more than 100, 000 p. p. b. of aflatoxin. That means

Figure 2.--Four "suspect" peanut kernels

Figure 3.--Half of a contaminated peanut kernel

that if there was just one kernel like this in a thousand, and none of the others had any aflatoxin at all, then the whole batch of a thousand would assay 100 p.p.b. of aflatoxin. You can see what is meant by the statement that most (or perhaps all) of the aflatoxin appears to reside in a few highly contaminated kernels. We have also analyzed different portions of the half kernel illustrated in figure 3; and we find, as you may expect, that the aflatoxin content differs in various parts of the kernel. For example, the part very near the black in the center analyzed more than 600,000 p.p.b.; the part that contains the germ, shown near the lower right corner assayed about 50,000 p.p.b.; a strip along the outer edge assayed about 200,000 p.p.b.; and the meaty portion in the middle assayed 250,000 p.p.b. It might be noted, for comparison, that when we conducted the peanut survey a year ago each sample we analyzed weighed 200 g. and contained roughly 500 kernels. Now we can, if we want to, analyze a single kernel or a part of a kernel, and it actually takes much less time to analyze the 1 kernel than it does to analyze a batch of 500 kernels.

Another phase of our work on aflatoxin entailed preparation of relatively large amounts of materials for use in feeding tests with various experimental animals. As part of this work we used special solvent mixtures to extract 200-lb. batches of five cottonseed meals selected by the NCPA, and then supplied the extracts to be used in trout feeding tests. The results of these feeding tests are just beginning to come in and it appears that the extract from a meal that contained about 300 p.p.b. of aflatoxin B_1 and 125 p.p.b. of B_2 is producing a high incidence of hepatomas in trout after about 9 mo. Another extract, prepared from a meal that contained about 25 p.p.b. of aflatoxin B_1 appears to be producing a low incidence of hepatomas. The other three cottonseed meals had no detectable amounts of aflatoxin and the extracts of these three do not appear to be producing any hepatomas.

We prepared hundreds of pounds of various peanut meals for long term feeding tests with rats. We made some peanut meal from the very best quality peanuts we could get--peanuts in which we could not find any detectable amount of aflatoxin--to try to establish that peanuts per se did not produce cancers. Then some of this meal was deliberately spiked with known amounts of aflatoxin produced by growing an active strain of A. flavus on shredded wheat. Then, using a relatively simple solvent system, we extracted a commercial meal that contained a high level of aflatoxin. This original meal, the extracted meal, and the extract are also being fed to rats. That feeding has been going on for nearly a year now by the pharmacology group in our Western Regional Laboratory at Albany, Calif.

More recently we prepared about 1,000 lb. of each of five different peanut meals containing graduated levels of aflatoxin for use in a swine feeding test. The swine feeding which is done at the University of California at Davis under the supervision of the Pharmacology Laboratory of the Western Utilization Research and Development Division was completed in April. The swine were fed for 90 days on rations containing 15 percent peanut meal. The aflatoxin content of the meals was 0, 10, 50, 350, 750, and 1,500 p.p.b. I am told that no significant differences have appeared between the animals on the 0 control diet and the highest aflatoxin level with respect to mean daily weight gain, and feed efficiency. All the animals have now been slaughtered but the pathology has not been completed.

It may be noted that there is a report in the literature that a toxic material appears to be secreted in the milk of cows fed toxic peanut meal (4). The toxin appeared in the milk 12 to 24 hr. after feeding of the contaminated peanut meal was begun and disappeared from the milk within 4 days after it was discontinued. The amount of toxin found in the milk was of the order of 1 percent that given cows in the feed.

On the other hand, there appears to be no particular problem with oil made from

contaminated seed. A certain proportion of the aflatoxin present in the seed appears in the oil. The exact proportion depends upon the processing condition, but it appears that most of the aflatoxin present in an oil is removed during refining and the last traces are removed during bleaching. Accordingly, since all our edible grade oils are refined and bleached, they do not appear to offer a problem with respect to the presence of aflatoxin in edible grade oils. However, if aflatoxin was present in the crude oil, much of it will be found in the soapstock, an area on which we have just begun work.

We have also done some work here on the removal or inactivation of aflatoxin in cottonseed and peanut products. We cannot at this time give you a procedure that you can take back to your plants and use tomorrow; but, several approaches look promising--methods of actual removal as well as chemical treatments for destruction or inactivation of aflatoxin. For example, the acetone-hexane-water mixed solvent developed to remove gossypol also removes aflatoxin. The aflatoxin goes into the oil, just as the gossypol does, but it should create no special problem because, as indicated previously, aflatoxin is removed during refining and bleaching of the oil. Also we have found that the mixed solvent and other solvents can remove aflatoxin from finished cottonseed and peanut meal without excessive loss of other material. The effect of various chemical treatments is now being studied and some of them look promising. We are not prepared to recommend any of these at this time, but hopefully, it will not be too long before we can.

What can you do to safeguard your cottonseed? Well, in a general way, we already know how to prevent loss and deterioration after harvest. The most important factors are mold contamination, moisture content, and processing conditions. We cannot do too much about simple mold contamination. Molds are everywhere and Aspergillus flavus, the specific culprit, is a very common one. But that does not mean that it is present everywhere in equal amount. Some seed will have more mold than will other seed. Good practice would call for not mixing highly contaminated seed with lightly contaminated seed. Under favorable conditions mold can grow extremely rapidly. So, it would just be good practice to segregate obviously moldy seed from seed that appears to be clean.

Incidentally, fat acidity correlates very highly with mold growth. It is now generally accepted that high free fatty acid in the oil in cottonseed is due to mold activity. In the case of peanuts there is also a high correlation between fat acidity and the percentage of samples containing aflatoxin as is shown in the table below:

Relation of Aflatoxin to Fat Acidity (12)

Fat acidity	Percent samples containing aflatoxin
<0.3	8
0.31 - 1.0	30
>1.0	70

Even relatively low free fatty acid may result in a large percentage of samples with aflatoxin. The most important environmental factors in growth of mold and production of aflatoxin are temperature and moisture. The optimum temperature for mold growth varies with the type of mold. Some like it relatively cool; some relatively warm. For example, when corn was stored at a relative humidity of 80 percent, a species of Penicillium was predominant at 25°C., A. flavus at 30°C., A. glaucus at 35°C., and a species of Mucor at 45°C. (8). The conditions that promote growth of A. flavus and production of toxins appear to be high humidity and relatively high temperature. The optimum temperature for the production of aflatoxin appears to be different for different strains of A. flavus but seems to lie in the range of about 75° to 95° F. On the other hand, it appears that relatively little growth of A. flavus and production of aflatoxin occur at temperatures below about 65° F. Moisture content is extremely important and will perhaps be the easiest to control. In the case of peanuts it appears that mold growth occurs very slowly, if at all, when the moisture content is below 9 percent. It should be emphasized, however, that this is the moisture content of the individual kernel and not the average moisture content. Uneven moisture distribution among kernels may result in mold growth even when the average moisture content would appear to be at a safe level. The mold produces moisture as it grows, so once fungal growth has started in one excessively wet kernel the moisture content of the immediately surrounding kernels also increases and further fungal proliferation may proceed regardless of the average moisture content. You may then have a pocket of highly contaminated material. And you recall, it is

our experience that the vast majority of aflatoxin occurs in a relatively very small number of highly contaminated kernels.

In the case of cottonseed the safe level of moisture content is somewhat higher, probably in the region of about 11 percent. Actually the safe moisture content is dependent upon the relative humidity, which in turn is dependent upon the temperature. As in the case of temperature, the optimum humidity requirement for mold growth varies with the type of mold. Milner and others (11) found that a strain of A. glaucus was the most xerophytic fungus (ability to grow at low moisture levels) that they isolated from stored grain. A. flavus requires somewhat higher relative humidity. If the temperature is low, more moisture can be allowed; if the moisture is low, a slightly higher temperature can be allowed. But it should be emphasized again that this is the moisture content of the individual cottonseed--not the average moisture content of a load or a warehouseful of seed. Good practice would dictate reduction of the moisture content to below about 11 percent and the temperature to below 60°or 65° F. as rapidly as is feasible.

Finally, one other thing. There is reason to believe that sound, undamaged seed is more resistant to invasion by mold and production of aflatoxin than is damaged seed. Certainly that is the case with peanuts. Damage to shells caused by improper harvesting provides an easy entry for molds. Similar damage to cottonseed during harvesting and ginning could be detrimental. Trashy cottonseed may be more susceptible to mold damage. Insect infestation should be kept at a minimum. The growth and metabolism of insects can provide environmental conditions suitable for mold growth (13), and insect infestation is almost always accompanied by fungus invasion. Field or storage damaged seed that have a high free fatty acid content have already suffered mold damage to some extent even though toxins may not be present. Such seed should not be stored with sound seed because they may provide the mold inoculation. Once inoculated and started, the necessary moisture and temperature conditions are readily established for production of toxins in the entire lot.

Summary

Molds in feeds have been a problem for a great many years, but the spectacular developments in England in 1960 relative to the "Turkey X" disease focused attention on the problem of mold toxins and gave a tremendous impetus to research. The presence of mold toxins is potentially the most serious quality problem that faces the producers, manufacturers, and handlers of food and feed products. One group of these toxins, the aflatoxins, which may be produced by the very common mold Aspergillus flavus is highly toxic to some animals. They produce cancer in some animals and are probably the most potent known carcinogens. It is potentially a problem for all agricultural commodities, not just cottonseed and peanuts. We at the Southern Regional Laboratory are carrying out only a part of a comprehensive Department program of research, which has for its broad objectives: (1) Determining suitable analytical methodology, (2) determining the effect of graded levels of aflatoxin on various experimental animals, including farm animals, (4) finding practical methods for preventing or at least minimizing mold growth in our commodities, and (4) developing processes for removing or destroying toxins in those lots of our commodities that may have been contaminated with toxin producing molds. We are cooperating closely with industry groups, such as the research committees of the National Peanut Council and the NCPA, and also with the Food and Drug Administration. The Department has instituted a comprehensive program of research on mycotoxins that embraces many agricultural commodities. Excellent liaison has been established and is being maintained by the Department with affected industry groups and with the Food and Drug Administration. The problem is an important one and it may be a serious problem. But it is just another problem, however, and it is getting much research attention. It is not something to get hysterical about.

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DISCUSSION

Question: What is the story on human toxicity?

L. A. Goldblatt: We don't know. Nobody has reported any evidence for toxicity to humans by aflatoxin. Obviously, you are not going to carry out experimental work on humans with such a material. We do know it is toxic to primates, monkeys specifically.

Sidney Masri: Leo, perhaps you can mention the incidence of liver hepatomas in the Bantus versus the incidence in the United States and Scandinavian countries.

L. A. Goldblatt: I agree with you on that, but nobody has yet analyzed their diets for aflatoxin so we cannot say the hepatomas are due to that.

Question: Has any research been done on finding chemicals that will neutralize these toxins?

L. A. Goldblatt: The answer is yes, and some of these researches are going on now. There are conflicting reports in the literature. As it is now, there is no feasible way that has been reported. We believe that it can be done. We are on the verge, I think.

Question: Is the ultraviolet screening test sufficient?

L. A. Goldblatt: Probably not. It should be backed up with biological tests like the toxin test. I think I would have more confidence in it now than I would have had 2 or 3 years ago, but it should be backed up with biological tests. I would say if the ultraviolet test is negative, it will be negative as far as aflatoxin toxicity is concerned. There may be other mycotoxins present, but not aflatoxin. If the ultraviolet test is positive, it may be a false positive if something else that behaves chemically like aflatoxin is present.

W. G. Hancock: I am from South Africa, and we have had our troubles with aflatoxin in ground nuts. I would like to reinforce Dr. Goldblatt's statement that this is nothing to get hysterical about. By the sort of cooperation you are using here, we have gone through 2 years without any serious trouble. I think cooperation between industry and government agencies is a very satisfactory way of solving the problem.

USDA PROGRAM ON PESTICIDE RESIDUES

by
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There are four divisions of the Agricultural Research Service which have a responsibility for pesticide residues occurring in and on food or feed. The Crops Research and Entomology Research Divisions are responsible for the research and recommendations for the control of plant pests (weeds), plant diseases, and insect pests. The Pesticides Regulation Division has the responsibility of registering chemicals for agricultural use and of enforcing regulations for the labeling and marketing of pesticides in interstate commerce. The Plant Pest Control Division has, during the past year, initiated a project to study the impact of pesticides on agricultural environment.

The economical production of cotton, in most areas, can only be accomplished with the aid of a number of pesticides. Before cotton is planted, the seed may be treated with fungicides or insecticides to control wilt and sucking insects as well as root-feeding insects. During the long growing period, weeds in cottonfields are most economically controlled by the use of herbicides. From 7 to as many as 15 or more applications of chemicals are made to cotton plants during the growing season to control insects and diseases. Chemical defoliants are also widely used as an aid to mechanical picking of cotton. Any or all of these processes could result in the occurrence of pesticide residues in cottonseed or in cottonseed products.

The Department of Agriculture has consistently endeavored to improve methods of cotton production. Prior to the development of DDT the pesticides used in cotton production consisted principally of arsenical, fluoride, sulfur, or copper compounds. These chemicals left no objectionable residue on cotton lint and were not usually found in detrimental quantities in cottonseed or cottonseed products. Research was soon able to demonstrate the superiority of DDT and other synthetic pesticides for the control of cotton insects and diseases. The cotton industry rapidly adapted these new tools to production without consideration of the possible problem of pesticide residues. While the chlorinated hydrocarbon pesticides gave excellent control of some cotton pests, measurable quantities of these materials remained in or on cottonseed. DDT residues in excess of 4 p. p. m. were found on samples of seed from plants treated with this insecticide.

As a result of these findings the Department of Agriculture recommendations now carry these safety restrictions for the use of pesticides on cotton:

(1) "Do not graze livestock in cottonfields treated with..." (This warning applies to 20 insecticides.)

(2) "Do not feed gin waste from cotton treated with (list of 10 chemicals) to livestock."

(3) "Do not use cottonseed treated with (list of seven chemicals) for food or feed."

Basing their evaluation on the research done by the Crops Research Division, Entomology Research Division, the States, and chemical industries, the Pesticides Regulation Division has approved labels for the use of 40 or more chemicals to control cotton pests. The movement of pesticides, under these labels, in interstate commerce is controlled by the Pesticides Regulation Division.

The preceding paragraphs are a brief review of the activities of the USDA in the field of pesticide residues. As we turn our attention to the present and future, I will limit the discussion to entomological research in progress and to studies of the impact of agricultural pesticides.

The ideal pesticide for use on any crop is one that would persist at a level adequate to control all pests and that would not leave a residue which was either toxic or obnoxious to the consumer. In our present thinking we could add "leaves no deleterious residue in the air, soil, or water." If it were possible, Agriculture would welcome any control method which would assure a disease- and insect-free crop without use of substances toxic to applicators or consumers. Currently the Entomology Research Division is supporting research in four areas--insecticidal

control, biological control, insect sterility, and insect attractants--in an effort to approach this ideal.

Insecticidal control. --Candidate insecticide materials are supplied by manufacturers and research chemists. These chemicals have generally shown some insect toxicity before they are forwarded to the Cotton Insects Research Branch laboratories for screening with cotton insects. Candidate chemicals are first screened against a number of different insects to determine their possible value as toxicants. In a second series of laboratory tests, candidate chemicals that have shown some promise in the screening tests are applied to cotton plants and tested against cotton insects. Phytotoxicity of the candidate chemicals to cotton may be detected at this stage of the study.

Screen cage plot tests are the next step in development of insecticides for control of cotton insects. In these tests, we learn something of the dosage required for insect control, obtain additional information on the phytotoxicity of the chemical, and possibly obtain our first evaluation of pesticide residues. Candidate chemicals are then ready for large-scale field tests and additional studies of the persistence of residues prior to recommendation for commercial use. One of the limiting factors in the development of a pesticide is the persistence of residues on or in the plant. These residues may be degradation products or metabolites, as well as the original chemical.

During 1964, approximately 50 candidate chemicals were evaluated against 12 insects that attack cotton plants. The purpose of this research is to improve insect control and to eliminate or minimize pesticide residues on cottonseed or cottonseed products. This summarizes very briefly the research in development of insecticides for use on cotton plants.

Biological control. --Biological control would, in effect, eliminate insecticide residues completely. Research projects in this field include the propagation of disease organisms which infect boll weevil (State College, Miss.) and bollworm (Waco, Tex.). Parasites of mites, bollworm, and lygus bugs are being studied at two stations. Most biological control methods are only 60 to 80 percent effective and are not adequate for control of insects in the highly competitive agricultural field.

Insect sterility. --The most dramatic approach to elimination of pesticide residues on crops is the use of the sterile-male technique for control of insects. In this technique insects are reared under artificial conditions, sterilized, and released to compete with untreated insects. By maintaining a high ratio of sterile to untreated insects, the population may be greatly reduced and eventually eradicated. This technique was successfully used in eradication of screw-worms from Florida and is being employed in the Southwest. The technique has been successfully applied to the control of fruit flies in the Pacific Islands.

Use of sterile-male technique depends upon the development of methods for rearing and sterilizing (without injury) tremendous numbers of insects, literally millions of insects per day.

Studies of the sterilization technique are in progress at both State College, Miss., and Brownsville, Tex. In addition, studies of methods of rearing insects on artificial media are in progress at several other laboratories.

Insect attractants. --The use of lures for control of insects could hardly be considered as new. Steiner directed the eradication of Mediterranean fruit flies from Florida by using an attractant with a mild phosphate insecticide. However, the isolation, identification, and synthesis of the sex attractant of the gypsy moth by Jacobson, Beroza, and Jones [1/] constituted a major "breakthrough" in insect control. The effect of this attractant is so dramatic that a major television network recently covered the trapping technique in a news special.

As a result of this study on gypsy moth sex attractants, major emphasis is being placed on the isolation, identification, and synthesis of sex attractants of other insects. Sex attractants have been discovered for male pink bollworm, tobacco budworm, and cotton leaf worm at Brownsville. The task of isolation, identification, and possible synthesis still remains to be done.

It might be noted here that while there is one project for control of cotton insects with

1/ Jacobson, M., Beroza, M., and Jones, W. A. Insect Sex Attractants. I The Isolation, Identification, and Synthesis of the Sex Attractant of the Gypsy Moth. J. Am. Chem. Soc. 83: 4819. (1961)

insecticides which might add to the present problem of residues in cottonseed or cottonseed oil, the Entomology Research Division is pursuing three projects for insect control which would leave no detrimental residue on the crop. Also, these techniques are relatively specific and would have no appreciable injurious effect on other arthropods or mammals.

Monitoring of pesticide residues. --No report of the activities of agriculture in the field of pesticide residue would be complete without reference to the monitoring project initiated by the Plant Pest Control Division in 1964. The purpose of this project is to determine the impact of pesticides on the agricultural environment. Five agricultural areas in Mississippi and Arkansas were selected for this study. The areas included fields in cotton, rice, and soybeans, pasture, woodlands, and streams, or ponds. The project outline calls for sampling of all phases of the environment (soil, water, plants, aquatic life, and animals) at regular intervals to determine the pesticide residues present and whether they increase or decrease with time. A part of the data from one of the sampling areas has been summarized. It would be unfair to judge it at this time; however, it does promise to yield some information on the degree of pesticide contamination of the environment that can be attributed to agricultural use.

DISCUSSION

Question: Have the residual tolerances for DDT and cottonseed meal been established?

J. E. Fahey: There is a tolerance of 4 p. p. m. for DDT in cottonseed, and the Food and Drug interpretation, as I understand it, is that the tolerance is set on a raw agricultural product. Any manufactured product would have the same tolerance. So it would be 4 p. p. m.

THE NEW HIGH CAPACITY 18-INCH SAW COTTONSEED DELINTER

by
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Last September, during the meeting of the Processing Research Subcommittee of the National Cottonseed Products Association, I was asked to give a report on the new 18-inch saw delinter at this meeting. It was expected at that time that the new installation of 45 of these machines at Greenwood, Miss., would be in full operation by about December and that information would be available to form the basis of a fairly complete report of their performance under regular mill operating conditions. A number of delaying circumstances have developed. Here I must hasten to say that these circumstances are by no means entirely chargeable to the 18 in. saw linter. The first part of week before last we observed the operation at Greenwood at which time approximately half of the linters were in operation under rather severe operating conditions. The mill shut down on Wednesday of that week and has since started up again with the complete installation in operation. Information collected during the visit to Greenwood has been supplemented by additional operating data from recent production reports from the mill which were made available at breakfast this morning.

Do not be discouraged about this report. It will be somewhat preliminary but does contain some information that you will be interested in. Please do keep in mind as you use this information that it is the best we have to date and is subject to revision after these machines have really had a fair chance to demonstrate their usefulness.

There are some things that can be said which are useful and probably will not be subject to much revision at a later date.

For one thing people speak of the 18-inch saw linter as "The Big Linter." It is bigger in several ways than the conventional linter. If you are thinking of installing the 18-inch saw linter in an existing lint room with the least amount of change, you immediately think "How much bigger is the new linter?" It is approximately 16 in. taller than the Carber M-4-S Linter from the floor to the top of the feeder, and the feeder has the same dimensions at the top as the old feeder. The new linter frame is exactly the same length as the old linter frame but the frame of the new linter is approximately 6 in.

wider than the old frame. The center line of the saw shaft on the new linter is 6-7/16 in. higher than on the old linter, part of this is due to extra 3 in. between the floor and the bottom cross rail which allows you to use a deeper conveyor box on top of the floor in larger mills.

The large saw, approximately 50 percent larger than the old saw, is largely responsible for the high capacity of the new linter. In order that you might observe the capacity potential of this machine more closely, a large saw and rib is available for your inspection and comparison with the corresponding parts of the old linter also available for comparison. In addition to the large saw, the float is also larger; the grate fall and seed board of the new linter provides a much larger capacity for the seed roll. The seed roll of the new linter contains about 104 to 107 lb. of cottonseed, while that of the old linters only holds about 40 to 60 lb. of seed depending on the lint cut and so forth. Even if the surface speed of the saw teeth was the same on the new and old linters, the new linter would have many more teeth in the seed roll at a given moment. There are also many more seed in the roll for the teeth to work on. This becomes more apparent when you consider that you still have 3/8 in. clearance between the saw and the float when you have 1-5/8 in. of saw projecting through the rib. This compares with 1/4 in. of clearance on the old linter with about 1-1/8 in. of saw projection. Many of the tests, which have been run with the new linter, have been at saw speeds of around 500 r.p.m. for first cut and up to about 700 r.p.m. for second cut. To obtain the same tooth speed on the old linter you would have to run your saws about 750 r.p.m. and 1050 r.p.m. respectively.

Tests, which have been conducted with the new linter under the conditions just mentioned, indicate that at these saw speeds the linter will handle from about 10 tons of seed per day on mill run leaving around 2-1/2 percent lint on the seed to almost 25 tons per day on first cut leaving 7.3 percent lint on the seed. In second cut service they seem to handle about 12 to 18 tons per linters per day depending upon the cut and so forth. Under these conditions the power consumption runs about 21 hp. for first cut, 22.25 hp. for mill run and 24.5 to 25.5 second cut exclusive of the flue system and conveyor load in each case. The data from these tests will be found in table 1.

Table 1.--Test results of an 18-inch saw linter, conducted by Carver Cotton Gin Co.

Type cut	Amt. saw in rib	Float clearance	Saw	Float	Brush	Delinted seed	Lint lb.	Total lint and seed	Lint cellulose	Lint left on	Resid. lint on feed	Tonnage 24 hr. approx.	Float	Saw
	In.	In.	R.p.m.	R.p.m.	R.p.m.	Lb.	Lb.	Lb.	Pct.	Pct.	Pct.	Lb.	Hp.	Hp.
2d cut	1-5/8	3/8	504	454	810	635	34.5	669.5	70	2.1	8.3	34,536	7.5	18.
2d cut	1-1/2	5/8	504	454	810	489	30.5	519.5	66	1.9	8.4	24,936	7.5	17.5
Mill Run	1-1/2	5/8	504	454	810	398	26	424	75.1	2.6	10.2	20,352	6.25	16
1st cut	1-1/2	5/8	504	454	810	999	19½	1,018½	80.6	7.3	9.9	48,888	6	15
2d cut	1-1/2	5/8	666	454	810	675	44	719	63.1	2.0	8.4	34,512	7.5	18
2d cut	1-1/2	5/8	717	454	810	690.5	40.5	731	62.0	2.6	8.2	35,088	7	18
2d cut	1-1/2	5/8	717	675	810	730	40	770	62.0	2.3	8.4	36,960	7.5	17

Most recent operating results from the 45-linter installation in the Yazoo Valley Oil Mill plant in Greenwood, Miss., are as follows:

	1st cut	2nd cut
Saw speed	525	630
Float speed	520	595
Brush	930	930
Tons of seed/24 hrs.	17	11
# of lint/linter/24 hrs.		
Lint cut #/ton	65-70	128-135

Some samples of first and second cut linters produced recently at the Greenwood mill were supposed to be here for your inspection. Many of you may be producing better quality linters than represented by these samples; but frankly, I believe there will be considerable improvement in the quality of the lint produced at Yazoo Valley after the installation has been operated for a period of time under more normal operating conditions.

It should be pointed out also that one might be able to make considerable progress in improving the quality of the lint produced by these large linters if he would be content with slower saw speeds and the reduced production that would result.

So far, nothing has been said about the air requirements of the large linters. Actually, I do not believe we know just how many cubic feet of air the linters require. The seed come out of the front of the 18-in. saw linter with considerably more force. There are a lot more seed coming out than is the case with the old linters. For this reason, a stronger draft of air through the linter is probably required in order to prevent lint from getting out with the delinted cottonseed and into the seed conveyor. The brushes in some cases are being run faster than is the case with the old linters; and, this too, is probably necessary in order to handle the quantity of air required and also to take the lint from the saw when the tooth speed is higher.

The tentative figure being used now is 2,600 cu. ft. of air per min. per linter for the new linter. A good average figure for the old linter on a flue system is about 1,300 cu. ft. of air per min.

There has been some speculation on saw cost for the 18-in. saw linter as compared to the conventional linter. A great difference in saw cost is not expected. One interesting question in this regard has come up. The 18-inch diameter saw is the same thickness as the old saw and is punched to fit the old duplex saw cylinder--this opens up the possibility of using wornout 18-inch saws on old linters equipped with duplex cylinders. Of course, the worndown 18-inch saws would have to be cut down to proper diameter for the old linters, which would involve some cost.

There are a couple of big things about the high-capacity linter that some people worry a little about. For one thing, the saw is so big that two ordinary men cannot man handle it; and some sort of device, such as a trolley system, must be resorted to. The other thing, some operators complain about is that the linter is so tall they cannot see or feel the seed roll without climbing up on a soapbox or something. It has been suggested that one might plan to have a raised section of floor in front of the linters or use basketball players for lint room operators.

In summarizing, it can be pointed out that it would be premature at this time to state that the 18-inch saw, high-capacity linter is a proven fact. A few answers are still needed. By the end of this operating season a lot more information will be available and possibly by that time the picture will be much clearer--so far as this particular machine is concerned. The important fact seems to be that the 18-inch saw linter is probably the greatest departure from the usual design that has come about in the past 50 years. For the past 50 years just about everything that has been done to the linter has been something to increase the machine capacity and in almost every case at some cost in lint quality. This has caused the development of lint cleaning devices which have really saved the day especially on second cut lint. The 18-inch saw linter does have a considerable advantage so far as capacity is concerned even if you compare it with the conventional linter with both operating at the same tooth speed. At the same saw shaft speed, the capacity advantage of the 18-inch saw linter is still greater. Possibly the larger saw and larger seed roll in the high capacity linter may overcome some of the

difficulties encountered in past attempts to increase linter capacity.

DISCUSSION

Question: Have you noticed any problem with nicking the seed?

A. C. Wamble: You are probably speaking of what we usually refer to as the linters hulling. I noted in the case of these linters at Yazoo Valley, the second cuts were hulling, probably not excessively but they were definitely hulling. This didn't discourage me too much because they would be expected to hull. Under the conditions these linters were operating, they were running about half of the linters and trying to get as much of their full capacity through the mill as they could. I thought they were doing a pretty good job, but from what I have seen I don't believe the large saw linter will hull much more than an ordinary 176 saw linter. This is something about which we need more information.

COTTON BATTING DEVELOPMENTS

by
William G. Davis
National Cotton Batting Institute

It's a pleasure to be here and to talk with you about these new developments in cotton batting. We are quite excited about them, and I know that you gentlemen in the oil mill business have quite a stake in it too, since this, while it does not represent a function in business, is an extremely important part of your profit picture. While I am here to fill in for Mr. Van Saun of the Janesville Cotton Mills, I think you know that it would be impossible to substitute for him. He has gained wide knowledge about the production of the new "Cotton Flote" over the past several years and would be able to provide you with complete technical information about the product and its manufacturing process. Instead of trying to do that, I will limit myself to reporting on the outlook for batting function with special reference to the effect "Cotton Flote" will have upon these markets. Full information on chemical formulations, chemical application, drying and curing, and the manufacturing techniques are available to you from the Southern Utilization Research and Development Division. Also, Mr. Van Saun and others in the batting business will be happy to furnish additional information if you need it. In fact, much of this information has been given you at previous Clinics.

First, I'd like to take advantage of this opportunity to let in any discussion of the market for linters and new developments in cotton batting; it is essential that we understand and appreciate the brokers and the dealers who perform a wonderful service for you and for the consumers of lint. When one stops to consider the fact that the consumer, no matter how small and often with a very questionable credit rating, can sit in his office in any part of the country and have the opportunity to select and buy linters from all over the producing states and many foreign countries, it is really amazing. The fact that they inspect and sample the output of some 190 oil mills, keep posted on the available supply of lint and on changes in production and seed conditions that affect the lint, and then guarantee to the consumer quality, quantity, price, and delivery, they perform a real service. I might add that I know of no firm that has ever lost a minute's production due to the failure of a dealer to deliver lint on time.

My subject this morning is "The Cotton Batting Market." As far as the majority of you are concerned, this is by far the most important market for lint and certainly the one in which I am more at home. As much as we dislike the competition which has been brought about by foam rubber, polyurethane foam, Tufflex and synthetic fibers, all these exciting products, if they had not been made available, would not have left enough linters to fill the need. We still have an over-supply of cotton, and since the production of linters is dependent upon the growth of cotton, there is not much prospect of seeing an increase in the production of linters in the near future.

On the other hand, we have been faced with the possibility that these competing products might take over completely in such fields as automotive pads and batting, furniture batting and cushioning, and in the bedding field.

Recognizing this possibility--and I might add that this in a few instances has been a

serious threat and not only a possibility--about 10 years ago, the bedding and felting industries along with the linter dealers and cotton waste dealers, with the help of the National Cotton Council, formed an organization called the National Cotton Batting Institute. The purpose of this organization was to promote the usage of cotton as a cushioning material. With the assistance of the National Cotton Council an excellent cotton advertising program is being directed toward the consumer by pointing out the desirability of cotton as a cushioning material.

During the past 10 years more than a million dollars has been used for advertising and research on the cotton linters which you produce. Also, through the financial support and moral backing of the Cotton Batting Institute, the National Cotton Council, the Textile Waste Association, and the American Cotton Linters Association, the Agricultural Research Service of the United States Department of Agriculture in their laboratory here in New Orleans have carried on a research program aimed at the development of new means of treating cotton linters and cotton waste to produce a better cushioning material.

I will discuss this further in a moment. For these past 10 years the consumption of linters and domestic felting and other nonchemical uses has remained fairly constant. There have been some peak years and some fairly low years, but these were brought about by the conditions of the economy in general. Cotton felt used in mattresses, box springs, and dual purpose sleep equipment accounted for about 49 to 50 percent of nonchemical consumption or approximately 380,000 bales. Automotive batting accounted for 24 percent or about 175,000 bales. Furniture cushioning and batting accounted for about 8 percent or about 60,000 bales. Other felting uses accounted for 10 percent or 75,000 bales. This makes a grand total of 750,000 bales of linters.

If you are interested in a full study--a very recent study of the market for linters--the Cotton Council has a new booklet available entitled "Cotton Linters, the Current and Prospective Demand." I would suggest that you get a copy directly from the Cotton Council.

Innerspring mattresses represents the backbone of the bedding industry, accounting for the major portion of linters consumption in the bedding products. By living standards prevalent in the United States, mattresses are considered a necessity and yet food, shelter, clothing, savings, medical expense, automotive needs, appliances, and almost anything you can mention generally rate a higher budget priority than mattresses. The fact that mattresses when in use usually are covered and not subject to visual inspection undoubtedly contributes to a relatively low replacement rate.

The mattress industry is now pushing the sale of oversized bedding in an all-out effort to make people realize that their old bedding is obsolete.

In 1953, 12 yrs. ago, innerspring mattress production accounted for 94 percent of all mattress production, and foam rubber 6 percent. In 1960 polyurethane came into the picture and the percentages changed to innerspring, 92 percent, foam rubber, 6.4 percent, and polyurethane foam, 1.6 percent. By the end of 1963, the sale of polyurethane mattresses had cut further into sales of both innerspring and foam rubber mattresses to the extent that innersprings--the ones using cotton linters--accounted for 88.3 percent, foam rubber 4.7, and polyurethane 7 percent.

From these figures, you can see that up to now, foam rubber and polyurethane foam have not actually represented a substantial threat to cotton batting in mattresses. There have been some performance problems and some associated with odor, setting in use and rapid deterioration under some conditions of use. Increased production of polyfoam at low prices and the ease of assembly, such as setting a mattress ticking around a foam slab, have led to numerous inferior products appearing on the market. A failure of the industry in its early stages to adopt standard specifications in its manufacture of polyurethane foam has been a source of dissatisfaction in the bedding industry. In the development of new cotton batting we are attempting to overcome this problem before it develops in that the laboratory and the major producers are developing very rigid specifications for the product. The quality of competing products is being improved and prices continue to get lower. Polyfoam now could begin to be a real threat to cotton in the mattress field. We in the industry, in anticipation of this, have been working hard to improve the quality of cotton cushioning in

innerspring mattresses, and I now feel that this resin treated cotton developed here in New Orleans may be the answer.

In the automotive industry, which is the second largest market for cotton batting, there was a strong trend to foam rubber cushioning in the early 1950's. This leveled off and lowered later in 1950 because of high cost and the new competition from urethane. Although auto manufacturers like the softness and resiliency of preformed rubber cusions, which were easy to install and retained good appearance in use, experience proved the cushions too expensive for the volume of cars. Furthermore, the bouncy characteristics of rubber cushions proved uncomfortable in some vehicles. For both price and quality considerations, the industry began using thinner foam rubber pads as toppers for cotton felt pads.

Polyurethane foam moved into automotive cushioning late in the 1950's on the basis of light weight, resilience, preformed qualities and particularly because of low cost. Urethane foam gained competitively against both cotton and rubber as cushioning materials. However, competitive gains against cotton have not been as rapid as initially predicted by some representatives of the trade. I might add that a short time ago--well, it's been 4 years now--we were advised by one of the major automotive companies that they were going to drop cotton altogether as a cushioning material and substitute polyurethane foam. Through the cooperation of the Cotton Council and the Southern Utilization Research and Development Division here in New Orleans we were able to postpone the implementation of this decision until such time as the results of the laboratory work could be presented to them and could be evaluated.

It is encouraging to note, however, that in 1953 an average of 24 pounds of cotton--that is cotton batting--was utilized per automobile manufacturer. At present--and I mean on 1965 models--this is averaging about 26 lb. The number of passenger automobiles made has risen from 5,700,000 in 1953 to close to 8,000,000 annually at present, resulting in a much greater total usage of cotton. Automotive manufacturers, unlike the major mattress makers, who garnett their own felt, purchase mattress felting from their own felters. In many cases, felts are preshaped and ready for assembly.

Although cotton batting traditionally has been the most economical material to meet performance standards, automotive seating engineers constantly are testing other material. As seating designs change and performance levels become more demanding, commercial felters will be forced to continue product improvements and modifications to maintain demand.

Now, here again we feel that this new resinated cotton may be the answer. Foam rubber and polyurethane foam lend themselves much more readily to the manufacture of furniture than they have to automobiles and mattresses. For this reason they have made tremendous competitive gains against cotton batting in the furniture industry. Because of cost, foam rubber is now used only in the more expensive furniture and polyfoam is used extensively in medium-priced and cheaper furniture. There are some objections to polyfoam however.

Earlier I mentioned the research work that has been conducted here at the Southern Regional Laboratory in New Orleans, and you have heard technical reports of this work in your previous Clinics. During the last 4 years the research people in this laboratory have developed a method for treating felt made of cotton linters and cotton waste with latex and resins. The lab has now perfected the process so that the resulting resinated, or bonded batt, has properties never before heard of in cotton. Exhaustive tests have proved that compression recovery under the most adverse conditions of heat and humidity is amazing. Tensile strength of the new product is terrific, and the batting can be molded to shape or die cut to pattern. It has a better shape retention than other batts and is free of odor. It can be made to light or soft density, or any variation of thickness in density desired. Tests show that resinated batts of high density provide better spring insulating qualities than other competing products on innerspring mattresses and for auto cushions and furniture, while batts of softer or lighter density provide a better cushioning material than polyfoam for mattresses, for automobile seats, and for furniture.

After exhaustive tests, the automobile producers have indicated an interest in buying the improved batting in commercial quantities, and I'd like to speak for just a moment about these tests. Previous to this work at the Laboratory, there have been

little--or I might say no--real test methods for determining the performance characteristics of cotton. It was only through the efforts here at the Laboratory, the Division staff working directly with the consumers, that tests were devised whereby the automobile companies and the major mattress manufacturers could objectively evaluate, not only cotton, but evaluate cotton in relation to its competition. After these tests, the automobile producers--as I said--have indicated a real interest in buying the new product. One of the top automotive trim engineers in Detroit told me that it is the only product that they have ever tested on an automobile cushion that came out thicker after severe tests than before the tests, and that he was simply amazed at the results. This was in reference to the batts made by the wet process or what we tend to call the New Orleans process.

It is the feeling of a number of important people in this industry that within a short time all of the cotton used in automobile cushions will be resin treated in one manner or another. The best estimate that we have been able to gather so far is that this will probably be within 5 years. Several cooperating bedding manufacturers have made up mattresses with these resinated batts as an insulator over the innerspring unit. In our opinion, and in the opinion of these manufacturers, it has the best feel on a mattress of anything they have ever used.

This, in addition to all its other characteristics, has made them very excited about its possibilities.

Gentlemen, this new batting process could very well be the answer to the future of cotton linters. In fact, it could be so good as to result in there not being enough domestic lint to fill the need, provided, of course, that the cost remains fairly stable. Considerable knowledge has been gained between the laboratory experiments and research and the actual setting up of a producing factory. At the present time seven companies have set up pilot lines through which they expect to gain enough knowledge to be able to go ahead with full-scale plants. They are using various engineering approaches to the use of the basic information provided by the laboratory here in an effort to keep a competitive edge against their direct competition. One company is now in production. A second will be within a few weeks, and I believe that within 6 months or so there will be four plants producing this batt on a commercial basis, and that by the end of this year, quite a number of manufacturers will have gotten into production.

I want to emphasize that there are risks involved, however. The cost of a plant to produce this new batting is fairly great. It is far in excess of the cost of a plant to produce the present type of cotton batting. In fact, it is so great that it is feared that some of the smaller felters will not be able to convert to such an installation. The product will only sell in volume if the cost is competitive with polyurethane foam, with Tufflex, with sisal, and with other products that now pose a threat to the uses of cotton. Should lint and cotton waste end up in short supply with resulting high prices, we could very well find ourselves in trouble with these new plants that are being built.

One of the top men in the auto batting industry made a very sound observation at a meeting here in the New Orleans Laboratory recently, and I will quote him. He said, "There is one bad thing about this new batt. It is so good that it could create a shortage of fibers suitable for its manufacture."

Let's not borrow trouble, however, because it is indeed a happy prospect for us to be even thinking of such a situation rather than being worried sick about what we are going to do with all of the inventories of linters and cotton waste, and what we are going to do with the batting plants made idle by products other than cotton. The battle is not yet won, but I feel that we are headed in the right direction. Real proof that it is the right direction has just been given to us. One of the big three auto companies has just issued engineering specifications on the new batting. They have issued the specifications and assigned a number to it which means that it can be purchased. Once that number is assigned, that is the important thing. They are planning to use it in the current model year. It will be used as an alternate material until production volume becomes more substantial. We have also been told, but not yet officially, that a second auto firm has also approved the product for current 1965 model production and will begin purchases immediately. We expect a third automaker to do likewise as his suppliers get into production. At the same time, mattress makers are anxious to use this new cotton material which we call "Cotton Flote" and will probably do so within the coming year.

I am truly sorry that Mr. Van Saun was not able to be with you this morning. He, more than any other one person in the batting industry, is responsible for the remarkable progress which has been made to commercialize the work done by the New Orleans Laboratory. He has served as chairman of the Co-operators Committee for this project since its inception. He had faith in its possibilities through good times and bad. He personally has spent a great deal of his time and probably thousands of dollars to pilot the way from laboratory to production. He has been free and open with knowledge gained in his own plant making the information available to others in the industry. He has asked me to give the highest praise possible before you folks here, to Mr. Vix and to Mr. Knoepfler and their associates at the Southern Laboratory, for their hard work, their fairness, and for the remarkable spirit of trust and cooperation that they have engendered among the felt manufacturers and their major customers. Here truly is one place where we are happy about the way our tax dollars are invested. I would also like to encourage you people to continue your support of this project together with other groups in our industry and to help capitalize on this new product that the Laboratory has developed. We see great things ahead within a relatively short period of time, and we must see the project through to its goal, that goal being new products, new markets, and we are hopeful, new profits.

DISCUSSION

Question: Can mill-run linters be used in this batting?

W. G. Davis: I think we might get two answers here. I will defer to Mr. Knoepfler for his technical evaluation as to what should be used. I do know of some manufacturers who, in their pilot operation, are using mill-run linters. They find that it is a little bit slower.

L. W. Mazzeno: Mr. Knoepfler, do you wish to add anything to that?

N. B. Knoepfler: Well, I can add a little bit to that. It will depend on the product for one thing. In the automotive industry, you are limited in that a number of the automobile companies specify the raw materials going into their products and they call for a mixture of first-cut linters and textile wastes of various grades. They do not permit use of mill runs or second-cut linters. They have had too many problems in the past with materials dusting out. With this new process, this can be reduced considerably. There would be very little dusting out. But we really haven't gotten an answer to that. In the furniture industry, we believe it could be used on some of the lower priced furniture.

Question: What kind of resins are used for this purpose?

N. B. Knoepfler: In general, the resins we use are of the same family of resins that are used in wash-wear treatments for cotton. The latexes that we use are the synthetic latexes mostly of the vinyl type. It would be either vinyl acetate or vinyl acrylic.

W. G. Davis: In some of the plants I have been through, in seeing their pilot operations, they are getting better results with the melamine resins, but they are coming up with some of the urea formaldehyde resins which are doing a pretty good job. I think this is largely because of increased cooperation and a great deal of interest on the part of the chemical manufacturers. They have been trying to come up with a formulation which would specifically be made for this application. And since the urea formaldehydes are considerably cheaper we hope that this does work out.

ECONOMIC OUTLOOK FOR COTTONSEED AND SOYBEANS

by
George W. Kromer
Fats and Oils Section
Economic and Statistical Analysis Division
Economic Research Service

It is a pleasure to be here today and take part in your conference. I was asked to present briefly the economic outlook for cottonseed and soybeans.

Before discussing the U. S. supply and demand prospects for the two major oilseeds, I would like to review some of the market highlights of the past 6 months. Then I shall move on to a sketch of the cottonseed and soybean situation and outlook, including the oil and meal products.

There has been a marked change in the overall economic outlook for soybeans and cottonseed and their products since late last summer. From a situation of prospective heavy supply of these commodities in August 1964, there is now a close balance between supply and demand for the 1964-65 marketing year. From a situation of continuing high stocks of cottonseed and soybean oils, there is now the outlook for returning to a more normal commercial carryover by September 30, 1965.

The complexion of the outlook started changing last August when the 1964 soybean crop was reduced by drought to about 700 million bu., the same as the year before, even though 1964 soybean harvested acreage increased 2.2 million to 30.7 million. The 1964 olive oil crop in the Mediterranean Basin turned out to be one-third less than the year before and export availabilities of oilseeds and oils from exporting areas such as Argentina, the Congo, and the Philippines, were reduced. These developments increased the demand for U. S. edible oil from dollar-importing countries along with the need for food oils from less-advanced (Public Law 480) countries. The result has been a significant increase in the world prices of all edible fats and oils. In the United States, wholesale prices of edible vegetable oils advanced about one-third from early August 1964 through January 1965, led by a sharp increase in soybean oil prices.

Another factor in the changed situation reflecting a shortage of feed in Europe and reduced availability of meal from Argentina, has been the increased export demand for U. S. protein meal. Europe's 1964 fodder crops were below average, thereby increasing mixed feed requirements for dairy and beef cattle. Pig and broiler numbers are up in Western Europe, thus requiring larger imports of mixed feed ingredients. Furthermore, rising consumer incomes have resulted in a greater demand and higher prices for livestock products. As a result of the combination of a fairly tight supply of soybeans in the United States and this strong export demand, meal prices are expected to remain fairly high during 1964-65.

With the background of these recent significant developments in the fats and oils industry, let us now turn to the outlook for the individual commodities. In order to facilitate discussion and analyses, I have a series of charts tracing changes and trends in the various sectors of the U. S. fats and oils economy.

Supplies of cottonseed in 1964-65 (starting stocks on August 1, 1964, plus the 1964 crop) are placed at 6.5 million tons, compared with 6.4 million in 1963-64. The season's crush is estimated at 6.0 million tons (assuming 94 percent of the 1964 crop moves to oil mills for processing), compared with 5.9 million in 1963-64. A crush this size will produce about 2.0 billion lb. of crude cottonseed oil (assuming yield of 335 lb. per ton) and 2.8 million tons of cake and meal (assuming yield of 940 lb. per ton).

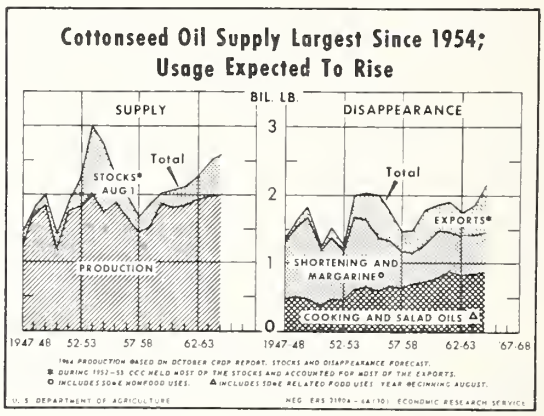

Figure 1

Cottonseed oil supply in 1964-65 is estimated at 2.6 billion lb., 5 percent more than a year earlier and the largest since the 1954-55 season. The increase is due mainly to larger starting stocks--they were 611 million lb. (crude and refined) on August 1, 1964, compared with 514 million a year earlier. The increase in the inventory was in CCC hands.

Domestic use of cottonseed oil is placed at 1.5 billion lb. in 1964-65, compared with 1.4 billion last season. Cooking and salad oil is the major outlet and now accounts for about three-fifths of domestic disappearance, compared with one-third in 1947. More cottonseed oil is being used in the manufacture of shortening and margarine this year than

last year because of the narrow price differential between cottonseed oil, soybean oil, and lard that has existed so far in 1964-65.

Exports of cottonseed oil in 1964-65 are estimated at 700 million lb., compared with 483 million a year ago. This increase largely reflects heavier exports under Title III foreign donations. The CCC acquired about 165 million lb. of cottonseed oil under the 1963 price support program. The Corporation has been selling its once-refined cottonseed oil and concurrently purchasing a fully refined salad oil for movement into the foreign donations program.

Based on above estimates for domestic use and exports, carryover stocks of cottonseed oil on August 1, 1965, will be around 400 million lb., which is one-third less than last year and the lowest since August 1, 1962.

Cottonseed oil prices (crude, Valley points) increased from 10.3¢/lb. in August 1964 to 12.1¢ in January 1965, averaging 11.2¢ for the 6-mo. period, or about 1.4¢ above prices the previous year. The seasonal peak in cotton oil output has passed and prices probably will remain firm, but may possibly increase. Prices for the entire marketing year ending July 31, 1965, probably will average about 2¢ or more per pound higher than the 10¢ in 1963-64.

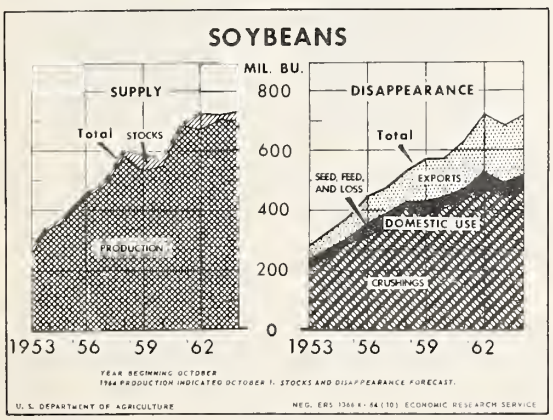

Figure 2

Soybean supplies are set at 732 million bu., compared with 714 million last year. The increase is attributed to larger starting stocks on October 1, 1964. Soybean crushings are expected to total around 470 million bu., compared with 441 million in 1963-64. Soybean exports are estimated at about 205 million bu., compared with 191 million in 1963-64. After an allowance of 47 million bu. for seed, feed, and loss, the carryover of old-crop soybeans on September 30, 1965, is expected to be at the low level of about 10 million bu., compared with 32 million last September 30. A soybean carryover of 10 million bu. is equivalent to only a few days' requirements for crushing and export.

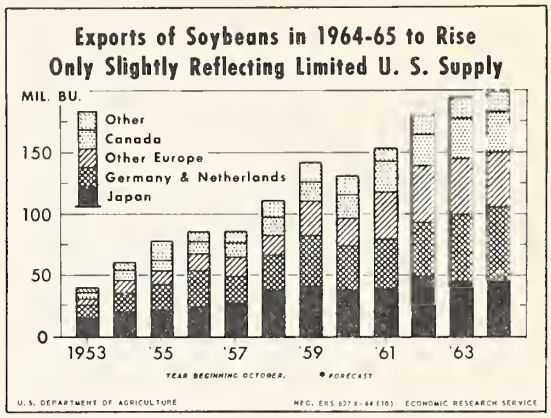

Figure 3

Crusher demand is greater this marketing year than last because: (1) Soybean oil stocks are down sharply; (2) domestic disappearance and exports of both soybean oil and meal are up significantly; (3) soybean oil prices are averaging higher, by a third; and (4) processing margins are averaging above last year's relatively low level.

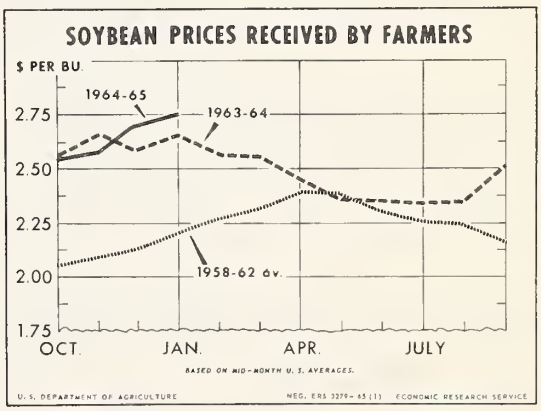

Figure 4

Soybean prices to farmers during October-January 1964-65 averaged $2.64/bu., about the same as a year earlier and 39¢ above the 1964 soybean support rate of $2.25. Prices during the balance of the marketing year are expected to remain strong, averaging well above the $2.43 received during February-September 1964. This price strength reflects increased export and crusher demand for beans, which has reduced soybean supplies below year-earlier levels.

Now I would like to direct your attention to the edible oils. First, let us examine export prospects by major categories.

Exports of edible vegetable oils (cottonseed and soybean) during the 1964-65 marketing year are estimated at about 2 billion lb., compared with 1.7 billion a year earlier. Exports under the Food for Peace program (all titles of P. L. 480) may total around 1.1 billion lb. compared with 0.9 billion in 1963-64. Soybean oil exports probably will account for about two-thirds of the total.

Highlighting dollar sales of edible oil this year is the return of Spain to the U. S. market after a year's absence. Spain had a very small 1964 olive crop (300,000 tons, compared with 650,000 tons in 1963), and as a consequence made sizable purchases of U. S. soybean oil in October-December 1964. Smaller olive crops in Tunisia, Italy, Portugal, and Greece also favor larger U. S. vegetable oil exports to the Mediterranean Basin area. Other major additions to the U. S. edible oil export market in 1964-65 include a P. L. 480 foreign currency (Title I) program with India. That country is a major producer of peanuts and other oilseeds, but edible oil consumption per person there is quite low.

A larger volume of U. S. edible oils will be exported in the 1964-65 marketing year as barter transactions. Initiated in mid-1964, this barter program replaces the payment of dollars to foreign suppliers for goods and services furnished to U. S. overseas installations. With butter in short supply for Food-for-Peace donation program, exports of vegetable oils under Title III programs will increase sharply in 1964-65.

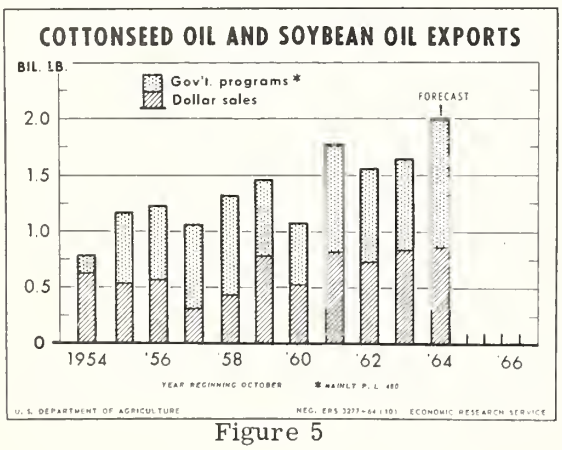

Figure 5

Vegetable oil barter program announcements since October 1, 1964, totaled about 65 million lb. Countries involved in barter transactions with the United States include the Canary Islands, Jamaica, Haiti, Morocco, Argentina, Australia, Greece, and Ecuador. In September 1964, about 31 million lb. of edible oils were exported to Burma under the barter program.

As oilseed processors, I know that you are fully aware of the competitive relationship between cottonseed and soybean oil prices due to their interchangeability and substitutability in manufactured products, such as margarine, shortening, and cooking and salad oils. Historically, cottonseed oil has commanded a 1 to 2¢/lb. market premium over soybean oil. However, in recent years there has been a slight narrowing in the differential as soybean oil has made inroads in the cooking and salad oils market. Figure 6 clearly shows the marked postwar downtrend

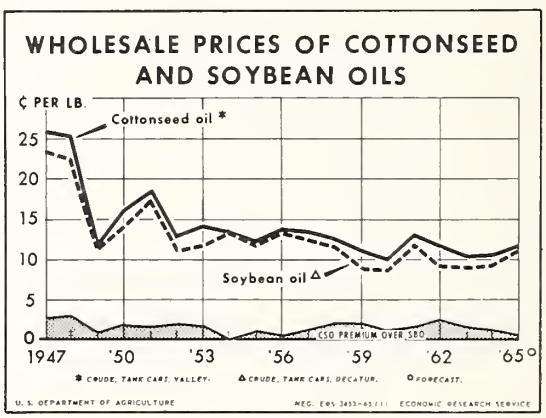

Figure 6

in cottonseed and soybean oil prices and how the two major food oils tend to follow the same price pattern.

The 1964 cottonseed crop initially moved to market at about $45 per ton (support was $44), but as oil prices rose, cottonseed prices to farmers increased to $49 in January 1965. Soybeans usually move to market later and over a longer period than cottonseed. For this reason, soybean prices have reflected more fully the rise in edible oil prices.

The rapid decline in soybean oil stocks combined with relatively high cottonseed oil stocks resulted in the elimination of the usual 1 to 2¢/lb. market premium of cottonseed oil over soybean oil during October-January

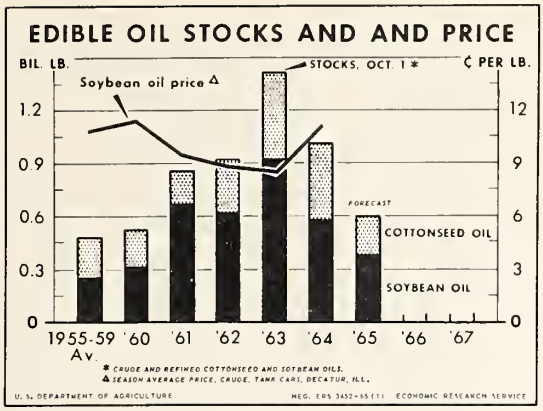

Figure 7

1964-65. As the excess cottonseed oil stocks are dissipated, a return of a small differential of cottonseed oil over soybean oil is likely though technological developments suggest that this spread may largely disappear.

In future years when the supplies of both cottonseed and soybean oil are plentiful, the price spread between the two oils probably will be quite narrow and many times erased.

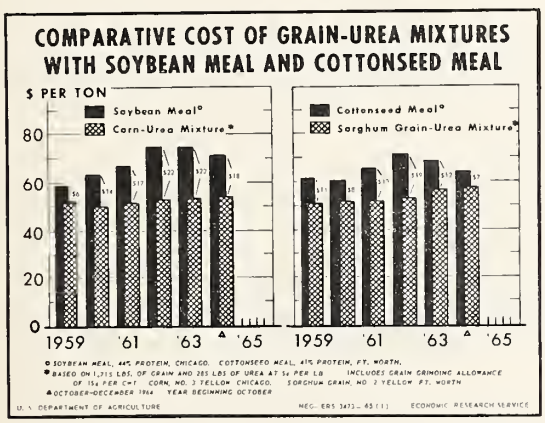
COMPARATIVE COST OF GRAIN-UREA MIXTURES
WITH SOYBEAN MEAL AND COTTONSEED MEAL
$ PER TON
Soybean Meal*
Corn-Urea Mixture*
Cottonseed Meal*
Sorghum Grain-Urea Mixture*
80
60
40
20
0
1959
'61
'63
Δ '65
* SOYBEAN MEAL, 44% PROTEIN, CHICAGO. COTTONSEED MEAL, 41% PROTEIN, FT. WORTH.
* BASED ON 1,715 LBS. OF GRAIN AND 285 LBS. OF UREA AT 5¢ PER LB. INCLUDES GRAIN GRINDING ALLOWANCE OF 15¢ PER CWT. CORN, NO. 2 YELLOW CHICAGO. SORGHUM GRAIN, NO. 2 YELLOW FT. WORTH
Δ OCTOBER-DECEMBER 1964. YEAR BEGINNING OCTOBER
U. S. DEPARTMENT OF AGRICULTURE
ECONOMIC RESEARCH SERVICE

Figure 8

Finally, I would like to pass on a few comments about the protein meal-urea relationship from the standpoint of competition and comparative costs. As most of you are undoubtedly aware, the use of urea (an organic nitrogenous compound) as a source of protein in livestock rations has grown rapidly in recent years, according to the limited data that are available. Its principal advantage is that it provides a low-cost source of protein for animals with ruminant digestive tracts when prices of natural proteins are high in relation to prices of cattle, sheep, and dairy products.

Domestic use of soybean meal declined about 5 percent during 1963-64 due to its relatively high price coupled with unfavorable livestock-feed price ratios. Sales of feed-grade urea increased.

Feed-grade urea contains 42 percent nitrogen and 1 lb. is potentially equivalent to 2.62 lb. of protein or about 5.36 lb. of 44 percent protein soybean meal. Urea must be fed with a carbohydrate based feed, such as cereal grains or molasses. The cost of urea mixture must be compared with oilseed meal costs. A typical practice might be to replace 7 lb. of soybean meal with 1 lb. of urea plus 6 lb. of corn or other feed grain. A price comparison of selected grain-urea mixtures and oilmeals during the past 12 yr. are shown in table 1.

In recent years, prices of soybean meal and cottonseed meal have increased more than corn and urea prices, resulting in a widening difference between costs of corn-urea mixtures and meal. In 1960-61, the difference between corn-urea and soybean meal was about $14 per ton on the Chicago market, rising to $22 in 1962-63, and averaging $21 in 1963-64. During October-December 1964, this difference averaged about $18 per ton, mainly because soybean meal prices were slightly lower.

If soybean and cottonseed meals are to compete with urea in ruminant feeds, they will need to be priced competitively at relatively stable levels. Wholesale prices of urea have been very stable in recent years--averaging $95 to $100 per ton (bagged, 42-percent nitrogen at principal markets East of Rockies). While feed manufacturers and cattle feeders likely will pay a slight price premium for soybean meal over urea, the difference must be narrower than the $21 per ton in 1963-64. A corn-urea mixture based on Chicago market prices would not have cost more than $57 per ton since 1956. It appears that soybean meal may need to be priced near this level to be competitive. This means that either the price of soybeans might have to be lower than in recent years or that soybean oil may have to carry a greater share of the price load for a bushel of soybeans. This latter is the case during the current year.

Table 1.--Comparative cost of grain-urea mixtures with soybean meal and cottonseed meal, 1951-64

Year beginning October	Corn-urea mixture and soybean meal				Sorghum grain-urea mixture and cottonseed meal			
	Corn, No. 3 Yellow Chicago	Corn-urea mixture 1/	Soybean meal, 44% protein, Chicago	Difference	Sorghum, grain No. 2, Yellow Ft. Worth	Sorghum grain-urea mixture 1/	Cottonseed meal, 41% protein, Ft. Worth	Difference
	Dol. per bu.	Dol. per ton	Dol. per ton	Dol. per ton	Dol. per cwt.	Dol. per ton	Dol. per ton	Dol. per ton
1951	1.826	72.70	89.95	17.25	3.16	71.00	89.55	18.55
1952	1.589	65.50	74.70	9.20	3.07	69.50	73.90	4.40
1953	1.534	63.80	85.30	21.50	2.78	64.50	65.10	.60
1954	1.475	62.00	67.00	5.00	2.51	59.90	66.20	6.30
1955	1.239	54.80	59.00	4.20	2.29	56.10	59.00	2.90
1956	1.312	57.00	54.35	-2.65	2.29	56.10	57.30	1.20
1957	1.211	53.90	60.40	6.50	2.20	54.60	54.80	.20
1958	1.207	53.80	60.50	6.70	2.23	55.10	63.55	8.45
1959	1.171	52.70	59.20	6.50	1.98	50.80	62.15	11.35
1960	1.096	50.40	64.30	13.90	2.04	51.80	60.10	8.30
1961	1.109	50.80	67.50	16.70	2.06	52.20	65.30	13.10
1962	1.189	53.20	75.20	22.00	2.13	53.40	72.00	18.60
1963								
Oct.-Dec.	1.175	52.85	79.50	26.65	2.25	55.35	76.75	21.40
Jan.-Mar.	1.207	54.10	79.30	25.20	2.29	56.15	73.10	16.95
Apr.-June	1.257	55.65	71.50	15.85	2.29	56.10	59.80	3.70
July-Sept.	1.245	54.95	70.60	15.65	2.32	56.55	63.95	7.40
Year	1.221	54.40	75.20	20.80	2.29	56.05	68.40	12.35
1964								
Oct.-Dec.	1.207	53.75	71.95	18.20	2.38	57.65	64.35	6.70
Jan.-Mar.								
Apr.-June								
July-Sept.								
Year								

1/ Based on mixture of 1,715 pounds of grain and 285 pounds of urea at 5 cents per pound. Includes grain grinding allowance of 15 cents per cwt.

SECOND SESSION

James H. Payne, Chairman

OUTLOOK FOR COTTONSEED PROTEIN CONCENTRATES

by
Aaron M. Altschul
Southern Utilization Research and Development Division

Last year at this Clinic I spoke on the availability of edible seed protein concentrates: I reviewed the status of the protein concentrates, the problems involved in using them properly for humans, and the opportunities resulting from the intrinsic value and quality of the protein in these seeds. I pointed out that there is now a potential existing for supplying for human use at least 20 million tons of protein annually from the three seeds: cottonseed, soybeans, and peanuts. This is the equivalent of the annual production of animal protein. There are, of course, problems of quality control, of removal of interfering substances, of producing food grade materials, of avoiding endogenous or exogenous toxins. None of these are insurmountable.

I also talked of the problem of structure in products from seed proteins, of making interesting products from these concentrates. There is no need to repeat this material; it is contained in the Proceedings of the meeting of last year which, I presume, some day will be issued.

Since then, I have had a number of experiences which should have broadened my

perspectives: I attended the meeting of the oilseed concentrates in Japan and continued on a lecture tour to several Japanese societies and universities. I visited Guatemala at Dr. Behar's invitation as a member of the Technical Advisory Committee to his remarkable institution, INCAP. In December I presided at a meeting called by UNICEF in New York to assess the status of cottonseed protein concentrates. A few weeks ago my book on this general subject entitled "Proteins--Their Chemistry and Politics" was issued by Basic Books. And presently I am organizing a symposium on the subject "Evaluation of World Protein Resources" for the American Chemical Society for next September. I should like to comment on the impact of these experiences on me as they relate to seed protein concentrates with particular reference to cottonseed.

First of all, I should say that there is an enormous and increasing interest in utilizing seed protein concentrates for human consumption in a modern way. And considerable know-how and skill is developing. At the meeting in Japan which attracted participants from every part of the world on this side of the Iron and Bamboo curtain, we were told that two-thirds of the soybean protein used in Japan goes directly for human food and that 10 percent of the protein in the average Japanese diet is soybean protein. We were given a vivid description by Dr. Lo of Hong Kong on the utilization of soybean milk. He made this a growing and profitable business. Its chief competitor was not milk because it was much too expensive: it was Coca-Cola. But he was able to compete on the basis of price and interest, with nutrition a secondary consideration. Now he has accumulated evidence to show the effects of usage on improved nutrition of the thousands of school children who snack on his milk during the recess periods.

At the meeting to be held in September there will be discussions of many of these subjects. There will be among other things a description of extruded products from whole soybean, a development in which the Northern Regional Research Laboratory had a great part; there will also be a discussion of lipid protein concentrates from peanuts; and a discussion of edible protein fibers and structured protein products.

One does not have to look far for the reason for this greater interest, more activity, more meetings, more research, and more progress: There are two kinds of needs that have to be filled, one in the underdeveloped countries and the other in the developed. Certainly every effort will be made to increase the supply of any kind of protein available in the underdeveloped countries, but the temptation to increase the supply of vegetable protein because of its lower cost will be so great that this need will have to be met in ever and ever increasing variety with a broader and broader base of raw materials, In the developed countries there is need, for medical reasons, to control nutrients; as we learn more about nutrition and medicine this need no doubt will be increased. Therefore, there is need for a broader base and for a wider selection of foodstuffs, both nutritious and interesting. Seed protein concentrates certainly deserve and are getting increased attention for this reason. These two needs and these two programs merge because, in the last analysis, there cannot be two classes of foods, one for the developed and one for the underdeveloped countries. Hence, whatever progress is made in either side of the problem should be reflected in helping to solve the problem in the other area.

Cottonseed products in particular are finding their way into serious food channels. I would not preempt Dr. Behar's comments, only to say that there is commercial production of cottonseed protein concentrates suitable for human consumption in Central and South America. There are commercial interests which are pushing the development of cottonseed protein concentrate food mixtures so elegantly pioneered by Dr. Behar's institution. The clinical and acceptance tests are most promising, and obviously this is just the beginning. Cottonseed protein has proven good value. Cottonseed protein has potential for higher-grade uses beyond the present uses or present expectations. Of course, a lot of what will happen is tied up into economics, which I do not wish to discuss. What I do wish to discuss is what we can do technically to accelerate the development of these higher grade uses. I should like to discuss in particular three subjects: (1) A serious practical deterrent; (2) the impact of basic research; and (3) some projections about the future of cottonseed protein.

It would seem that the most serious problem deterring further expansion of uses of cottonseed protein concentrates in high-grade animal and human diets is the presence of

gossypol in any form. The present concentrates which are now used for humans are doing well--very well. And one might be tempted to say: "Enough, we have solved the problem." But cottonseed protein concentrates do cause problems in sensitive animals such as with growing swine or in laying hens. As long as these problems exist we must infer that the present processing techniques, as useful as they have been in introducing cottonseed into these higher markets, must be improved. I certainly am proud of the role of this Laboratory in aiding the industry to reach the stage it is in now. Nevertheless, for maximum use, gossypol must be eliminated completely. There are many of you here who are tired of talking about this problem or hearing about it, I can hardly blame you. I too am tired of hearing about it every year. And maybe some of the people who have been doing research in this area are getting tired of working on the problem. This makes all the more remarkable the perspicacity of the research leaders of this industry who are constantly pushing this matter forward. What is the status of our efforts?

I would only mention that one of the brightest spots is the breeding problem, the introduction of a gland-free variety. I am not in a position to evaluate the status of this problem. I know that it is going ahead. I know that there are some potential difficulties, but all of the people in this work are optimistic that in the 1970's there will be serious amounts of gland-free cottonseed in production in the United States.

As a chemist, I would have hoped that one could move faster by cultural evolution, that is by devising new techniques, than by genetic evolution, or at least combine the two to yield better products. At the moment--I would hope that this is wrong--there is the feeling that there are no current practical processing procedures which remove all of the gossypol from the meal without introducing other problems which raise the question about their efficacy. It is possible to make in the laboratory fine meals almost devoid of gossypol, but the practicality of these matters have yet to be demonstrated. Perhaps one of the difficulties is that attempts have been made to do them all at once--remove both the oil and gossypol at one time. I suggested at the last cottonseed conference a year ago that this might be too great an ambition and that perhaps a two-stage process will work.

Many years ago Charlotte Boatner[1/] suggested a separation process to remove the pigment glands from the seed and this yielded a very fine cottonseed flour. The whole idea of this type of separation might deserve a second look. In our own laboratory we have succeeded in separating many of the cellular constituents of seeds by nonaqueous separations; and perhaps this process either in a dry or in a nonaqueous state might be worthy of further consideration.

There has been a renaissance of interest in the action of iron to neutralize gossypol. Dr. Lyman has stated that for pig rations he prefers cottonseed meals that have been extracted with the minimum amount of heat damage to which he would add iron salts to neutralize the gossypol. Under these conditions he has never had any fatalities with pigs. Dr. Bressani at INCAP has had similar experience in his laboratory, and Dr. Danhoff has demonstrated that one can neutralize the effect of gossypol with iron. It may be that this view is worth serious consideration.

One might be tempted to think that too many different approaches are being investigated simultaneously for the removal of gossypol. It might be possible that thought ought to be given to consolidate efforts on the most promising approaches, and perhaps to look for new ones.

This I can say with certainty. Once the gossypol problem is solved there will be vast new opportunities for cottonseed protein in human foods and for sensitive animals.

The second subject I want to take up is at the other end of the spectrum. It is basic research not designed to solve practical problems but to contribute to our knowledge in general and to our knowledge of subjects involving cottonseed in particular. I was amazed and taken aback when the National Cottonseed Products Association awarded a Fellowship to my laboratory for basic research without asking for any specific problem-solving in return. I was flattered at the confidence and, I must confess, somewhat overwhelmed by the responsibility that was involved. But now after a few years of experience, I feel a little more confident about the contribution that we can make. When the Fellowship was first given, the amount of effort on cottonseed in my laboratory was very little; now it is over 50 percent of the total effort. When we started the research we had no knowledge of

1/ Formerly of SURDD.

the architecture of the cottonseed parenchyma cell which is the major cell in the cottonseed kernel. We now have it mapped very precisely; an article describing the cottonseed cell architecture has now been accepted for publication in the Journal of Molecular Biology. A second paper by Dr. Engleman, the current Fellow, will be sent shortly to another Journal. We know where the protein is and where the oil is. We know how to begin to identify various portions of the seed with certain constituents, and we know how to follow changes in the seed with the aid of this powerful tool.

We are coming closer to the time when we will have purer seed proteins so that we may be able to generalize about the proteins in seeds. We've learned how to modify seed proteins so as to increase their solubility and to enable us to do more with them.

Methionine is one of the important amino acids in seeds from a nutritional viewpoint and one of the scarce ones, yet little work is being done on the conditions and reactions of methionine in seeds. I have a student at Tulane who is now studying the reactions of methionine in model simple systems and this work is being supported by a Fellowship from a major food company.

What is more exciting in basic research is that in other laboratories who do not have the correlative interest in cottonseed that we have, cottonseed is being used as a tool for studying major problems in plant physiology and protein synthesis. As more papers from others and our laboratory appear on strictly basic aspects of this problem, we feel sure that others will be encouraged to turn to cottonseed as a model in biochemistry, and then the cottonseed industry will begin to get research done on its seed without any cost to itself, but simply as something that biochemists will become interested in.

I hope that we will continue to merit the confidence of the cottonseed industry in our basic research program and hope that when we lose it, the industry will lose no time in withdrawing the Fellowship.

Let us conclude with some comments on an attempt to assess the future of cottonseed protein. It is difficult to predict, particularly the economic aspects of the problem. One would not have predicted twenty yrs. ago or so when the major research program at this Laboratory on cottonseed was started that cottonseed would now have the role it does play in nonruminant feeds and in human foodstuffs. Many of the mixed feed producers now use cottonseed interchangeably with other protein concentrates depending on price; one major producer, at least, is now offering a 50 percent cottonseed protein concentrate for more sensitive animals. Cottonseed protein concentrates will seek and attain higher quality markets. Actually, there is no choice. Cottonseed protein is good and economics will eventually demand that it be used to the maximum advantage. The competition for the lower priced markets, that is for the ruminant animals, is increasing. We used to talk about urea as a competitor and it still is, but there is also raw cottonseed itself, and at the September ACS meeting there will be papers on proteins from petroleum--an entirely new source of protein--and of upgrading carbohydrate roots by mold mycelium. These will first go after the least discriminating markets, but eventually they will try for more discriminating markets.

But the upgrading of cottonseed protein concentrates will not be automatic and will come only to those segments of the cottonseed industry which are willing to treat cottonseed processing as a food science and will devote to its processing and improvement of quality, the competence and the care which the raw material deserves and the opportunities dictate.

DISCUSSION

Question: I am curious as to whether you have seen the same distribution in soy cotyledons that you have in cottonseed.

A. M. Altschul: We haven't done it, but we have examined the electron micrographs of others, and the answer is yes.

Question: Are there any indications from your micrographs as to where the gossypol might be? Is it in the oil sac, protein sac?

A. M. Altschul: We used glandfree cottonseed purposely to avoid that problem, but for that you don't need an electron micrograph. The gossypol is in glands which are extracellular.

R. A. Phelps: I would like to make one comment. I think Aaron is not quite as optimistic about the iron work as some of the rest of us are. I would like to point out that there are

two more laboratories that have confirmed that iron counteracts gossypol effects, Aaron, using levels of gossypol up to four times the amount required to kill a pig. As long as there was a ratio of 1 part iron to 1 part gossypol, the pigs performed satisfactorily.

A. M. Altschul: May I comment on that? I agree with you, Dick, and I think that it's a very serious matter. The question that was raised was whether one could convert that nutritional and toxical information into actual practice for human foods without having problems of color and the like. Maybe one doesn't. I certainly think it is a very serious possibility that ought to be looked at. I am referring to the whole idea of considering chelating agents, and to not necessarily limit it to iron.

R. A. Phelps: Incidentally, zinc and copper did not work.

Question: Dr. Altschul, these fractionations that you refer to are intracellular entities (protein lipids), but is there also a difference in that any 1 cell or morphological part of the seed would have more of 1 of the components than others?

A. M. Altschul: I can't give you a complete answer. All of the four slides that I showed you were of the same type of cell, parenchyma cell. We find that when we go to vascular tissue we get different distributions and I am sure that when we go to the axial tissue, which is the growing portion, we will again find different distributions. But I should say that since the parenchyma cell would be 90 percent of the cells of the cottonseed, this is the most predominant kind of a distribution.

REQUIREMENTS OF FLOURS FOR HUMAN FOODS

by
J. L. Gabby
Mead Johnson Research Center

Before starting to discuss the topic assigned to me, I think we had better have some definitions so that we can all start from the same place.

Requirements is a word I think we all understand. To a salesman, it means the amount he can sell to a customer; to a buyer, it is the amount he has to buy at the lowest possible price; to a nutritionist, it means proteins, fats, vitamins, and so on, and to a food technologist, it means all of these plus a list of physical and chemical attributes for a product he wants to make.

Flours can include just about any dry material that is finely ground. For our purpose this afternoon, I am going to arbitrarily restrict this word to a narrow meaning--we will include only flours which are high-protein materials but we will include any state of subdivision small enough to be considered edible.

I am sure we can argue all afternoon about this word "human" so I will combine it with the word "food" to make "human food" and refer you to the old farmer who said he would eat anything his horse would, except hay.

Now that we have arrived at a starting point, there are a few more ideas we need to establish.

It is a good bet that if I should ask the general question, "Which class of food constituents (carbohydrates, proteins, or fats) is the most desirable, the most sought after, or the best tasting?"--the answer predominantly would be "proteins". All of us are aware that there is a shortage of protein in the world and that a great effort is being made to provide proteins for the people of the developing countries.

On the other hand, I am sure all of you are aware that the people of the Tropics who live on cassava do not eat the tops of the plants which contain good protein but rather they eat the carbohydrate from the root. They go to great lengths to purify the starch before they eat it. If as many years and as much time had been spent extracting and purifying the protein from the leaves as was spent on the roots, there would be no protein shortage today.

Nature did a very poor job of making proteins palatable. She did mix them with moisture and fat in our meats and with carbohydrates

in milk and plants. The only humans I know that like a high protein food as it is produced by nature are tiny infants. I can see that some of you are waiting to say that you are not infants and that you still like milk. I have a question for you, "Don't you want it taken from the cow, placed in a container and refrigerated to make it cold?" Nature never did produce a glass of cold milk.

All of us have our favorite recipes for preparing delicious dishes from meat, fish, eggs, and so on. These vary widely as we go around the world. Only one thing seems to be common to all people and that is they do not like proteins as nature provides them.

From the standpoint of the Food Technologist today, we have established our first and most important requirement for flours. They must be palatable to humans, or be in such a form that they can be made palatable.

We all know that humans can live on completely synthetic diets using amino acids as the source of nitrogen. After talking to some of the long-suffering subjects who have allowed themselves to be used for such tests, I have come to the conclusion that it is questionable whether life is worth living on such diets.

From my own experience, I would say that no flavor at all would be best for a flour as we have defined it.

This flour should have either no texture or a texture that is pleasing to a human. So far as the color is concerned, we cannot generalize because each food has its own peculiar color. Usually we associate a light color with quality and the browning reaction with proteins so we need a light-colored flour for a starting material.

The three most important requirements of a flour are the lack of flavor, pleasant texture (perhaps, we should call it "mouth feel"), and light color. These are factors you will also recognize in the most widely used foods of the world--rice, wheat, cassava, potatoes, and perhaps a few others.

I feel certain you expected me to say that protein quality was the most important requirement. One question, "What good is a perfect protein if no one will eat it?"

If any of you have ever tried to flavor foods that contain high levels of proteins, I am sure you will agree that it is a difficult task. When you get past salt, M. S. G., and spices for nonsweet products and chocolate for sweet products; you have troubles.

To say that protein quality is unimportant is the farthest from my intention. We spend a great deal of money testing the quality of protein-containing materials. Whenever we find a possible new source, we look at it from the Product Development standpoint; and simultaneously, our Nutrition Department tests it for nutritional qualities.

Since this is a Cottonseed Processing Clinic, let us take a look at what our Nutritional Department has to say about cottonseed flour.

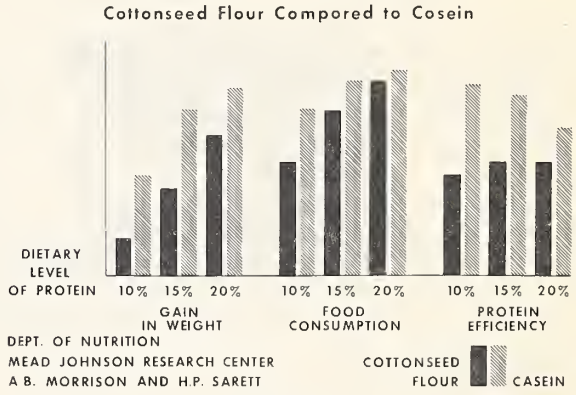

Figure 1

As we look at this figure we see the story of a comparison of a rather complete protein, casein, and one not so complete, cottonseed flour.

As we examine the first set of bars, we find that with both materials the gain in weight goes up as the level of protein goes up. It is interesting to note that as the protein level goes up the growth produced with the less complete protein more nearly approaches that with the complete one.

The second set of bars I show to point out two facts. First, part of the lack of growth is due to the fact that the animals will not eat as much of the incomplete diet with the low level of protein. Second, as the level of protein increased, the amount of food consumed on both diets approached the same level. In animals one thing that will keep them from eating a diet is an incomplete protein. This may possibly relate back to what we said earlier that no product can be good if we won't eat it.

The third set of bars brings together the first two sets in what we call protein efficiency or units of gain per unit of protein consumed. These are more meaningful figures for comparison so, in the other figures I want to show you, we will confine ourselves to just these expressions. You will note here that as the level of the incomplete protein increases, the protein efficiency does the same. In the case of the complete protein, the reverse is the case.

When we ask the food technologist about cottonseed flour, he is interested in special attributes of the product which will do special things, since it is not a particularly desirable source of protein so far as nutritional qualities, flavor, texture, and color are concerned.

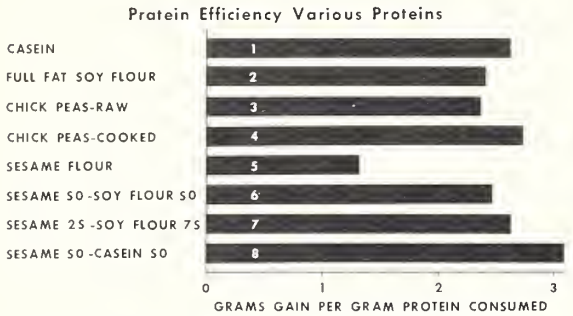

Figure 2

Which protein we select is important. What we do to it is also important. This figure points out some of these things. Here we have turned the bars in the opposite direction but the relationship is the same. We again start with casein as a standard of comparison. We find that from time to time there are variations in the way rats will grow on diets containing casein. We always have one group on this diet to relate one feeding test to another.

As you see the Full Fat Soy Flour is not as good as Casein, but it is quite good.

Chick Pea Flour presents an interesting picture. This seed is used as food in many places around the world. It is called different names in different places. Sometimes it is called a gram while at other times it is "garbanzos." This flour, made by simply grinding the whole pea, contains a protein of quite good quality. This is shown by the third bar. Cooking improves this flour as it does soy flour. After cooking, bar four shows a protein efficiency almost as high as casein. This is one of the finest vegetable proteins we have. Except for the fact that this seed contains only 20 percent protein, it meets all of our three requirements for a high-protein flour of flavor, texture, and color.

A flour made from sesame seed doesn't contain a very good protein, as indicated by bar number five, but we are all aware of its value as a food. Fortunately, sesame contains an unusual protein high in the amino acid, methionine, which supplements many others. As you see in the next bar, a mixture of 50 parts soy and 50 parts sesame is slightly better than either one alone while a mixture of 25 sesame and 75 soy is still better. We usually think of casein as an excellent protein; but in this particular test, even it is slightly improved by sesame. Here we have an example of a protein that meets our three original requirements of taste, texture, and color; but by itself, it isn't much good nutritionally. Nevertheless, we have to class it as a valuable food.

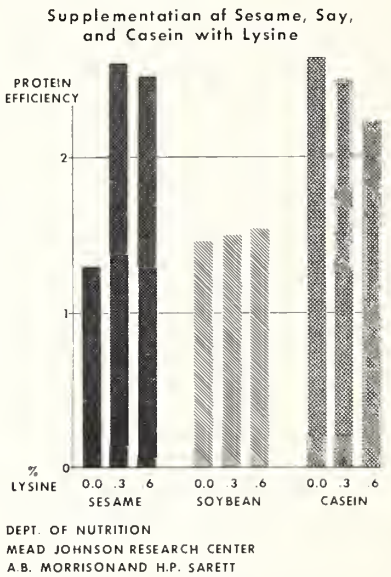

Figure 3

Lysine is the amino acid missing in sesame protein so that when it is added to this protein at a level of just 0.3 percent of the diets, the protein efficiency jumps to a figure equal to casein. Since soy protein has plenty of lysine, the lysine addition has no effect. Casein has an abundance of lysine so that additions actually tip the balance over the other way and tend to drop the efficiency value slightly.

Since sesame can be easily put into delicious forms, it is widely used. Soy is difficult to make taste very good to us in this part of the world so it is not widely used. Casein, on the other hand, lends itself to all kinds of manipulations. We know it in the many forms of cheese.

Why are we interested in high protein flours for human foods? If the present situation as it exists in this country was expected to be the situation in the whole world for the next 100 years or so, the answer would be--"We are not interested." However, we are all convinced that this is not the case. Already many places in the world are overpopulated to the point where the people cannot get enough to eat. If forecasts are correct, our own country is headed in that direction. Before we become short of food for humans, we will eliminate animals and poultry as in-between converters of plant materials and eat the plant products ourselves.

If tomorrow this situation should present itself, what could we do? First, we would have to change our eating habits and decide that we enjoy eating plant products without meat, milk, poultry or eggs. We already know enough to do a pretty good job. This next figure gives a simple example of what we can do for animals and this can be translated to humans.

Vegetable Proteins V.S.
Whole Milk Protein

	VEGETABLE PROTEIN	WHOLE MILK PROTEIN
GAIN IN WEIGHT	163	173
FOOD INTAKE	508	466
WATER INTAKE	853	829
FOOD EFFICIENCY (grams gain/100 grams food)	32.2	37.1
LIVER WEIGHT	6.3	6.6
KIDNEY WEIGHT	1.43	1.43
ADRENAL WEIGHT	35.3	36.7
THYROID WEIGHT	20.8	20.0
LIVER SOLIDS	28.4%	28.4%
LIVER FAT	4.5%	4.6%
LIVER PROTEIN	22.6%	22.3%
PROTEIN CONTENT OF THE DIET	15%	15%

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Figure 4

The vegetable protein was a mixture of corn flour, oat flour, wheat flour, and soy flour. The whole milk protein was simply dried whole milk.

When we accept the fact that the whole milk gives us about as good a protein as can be found, we see the mixture of plant materials is pretty good.

The gains in the two groups were close together. Food and water intakes were not far apart. The food efficiency which reflects the above figures indicates the milk is still the most efficient. Perhaps, this change in diet might be welcomed by some overweight Americans; they could eat more and gain less. On the other hand, trading steaks and cheese for pancakes might not be accepted.

The other figures on this figure simply indicate there was nothing wrong with either diet. The internal organs of all the animals were practically the same.

To tell any of you people what to do to your cottonseed products would be a presumptuous undertaking on my part. I have pointed out in an indirect way some of the things we would like to have in a flour as we have defined it.

Most of my experience has been in the field of soybean products. I would like to give you some bits of data from a report I wrote on work done for the Glidden Co., now Central Soya Co., of Chicago. The report was dated 1945 so I'm sure there is nothing new in it but it illustrates a point I want to make; namely, that a great deal can sometimes be done to a natural product by very simple procedures. Sometimes it takes years to find a simple solution. No one today will say that soya products, as we have them, are perfect from any point of view. They are still too high in flavor to be used in many products in large amounts. Sometimes their functional properties are fine while under other circumstances the same properties may be unwanted. At the present time soya products are used in small proportions or in rather highly flavored foods like sausage.

In those days, 20 years ago, we talked about the heating of soybean oil meal to improve its digestibility. Since feeding tests were long and costly, there were many methods proposed for measuring the effect of treatment given a particular soy product

without using animals. Urease activity, color, protein solubility, and viscosity were some of these. We set up our experiments to measure the changes that took place under certain conditions by measuring these factors in addition to feeding tests.

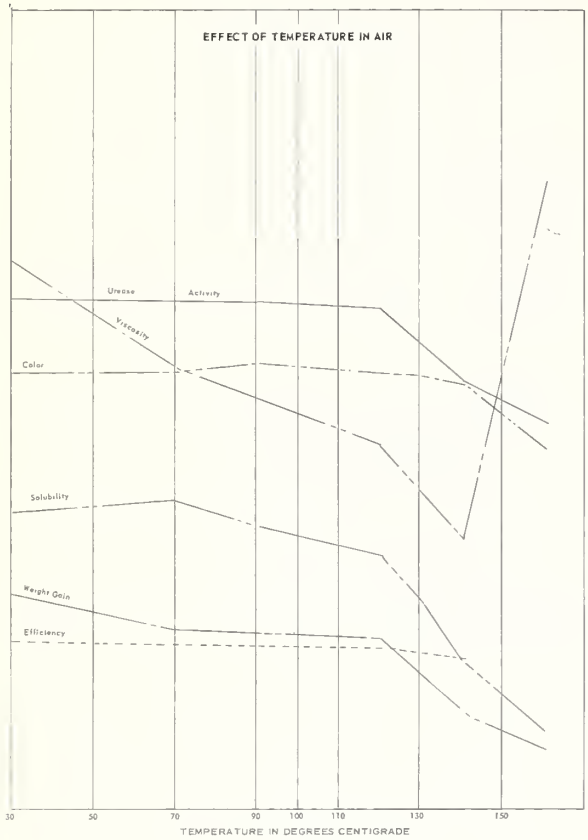

Figure 5

The pattern on this figure shows the results of heat on hexane extracted soybean flakes. The important thing shown here is that heat alone did very little until rather high temperatures were reached and even then the changes were not dramatic. You will note from the chart that there was very little, if any, activity until 140°C. was reached.

It was back in those days that the classic patent of the Soybean Industry was issued to Kruse of Central Soya Co. on the processing of soybean meal having a high moisture content. His patent taught that in order to produce soybean meal of high nutritional value, the flakes should contain more than 17 percent moisture at the time they were toasted.

From this and other work in which people reported autoclaving soybean products, we decided that moisture was the thing we should study.

An attempt was made to replace the air by water vapor. With the equipment we had at that time, we were not completely successful; but we did the best we could, and, I believe, showed an accurate picture in spite of the fact that some of the lines on my next figure are a bit wiggly.

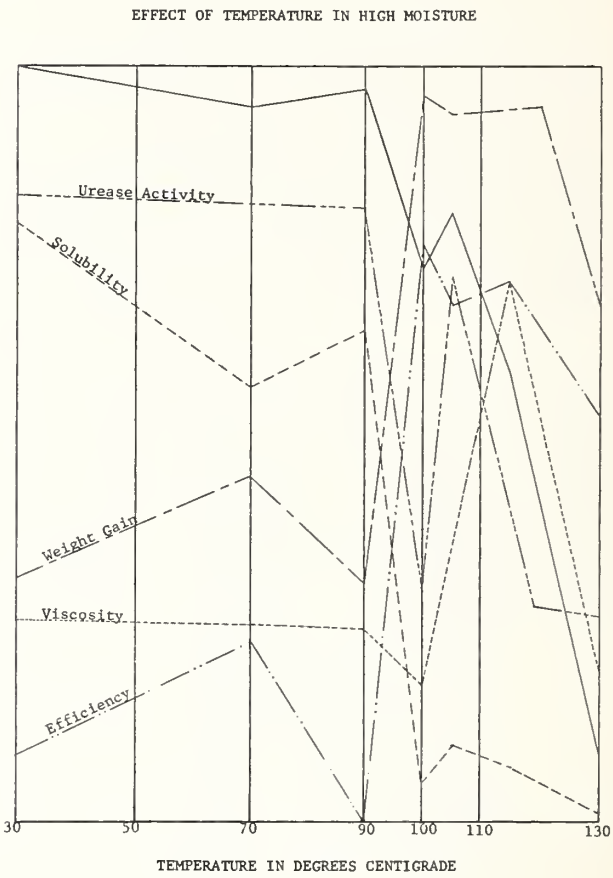

Figure 6

You will note from these curves that things began to happen when we arrived at 100°C. in the presence of moisture. We got, for all practical purposes, a maximum effect under this condition. Higher temperatures, which, of course, were produced by pressure, had little or no additional effect.

With this information available, we then attempted to determine the length of time required for these various reactions to take place under these conditions of high humidity

and temperatures at 100°C. This data I present in figure 7.

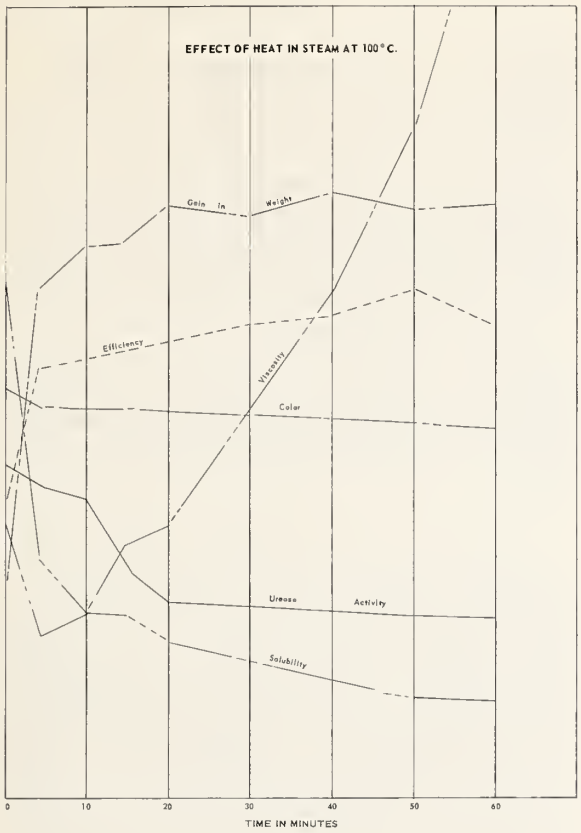

Figure 7

For the most part we could eliminate the last 80 percent of our chart because with the exception of changes in viscosity everything happened within 5 min. In subsequent studies we found that 1 min. was usually just as good as 5 or 10 except that we had mechanical problems in attempting to produce such a set of conditions.

It was our conclusion that time was completely unnecessary if we could have arranged ideal conditions to have raw soy products in the presence of moisture at 100°C.

By this simple treatment of raw, extracted soybean flakes with moisture and heat we could vary the physical state of soybean products to suit ourselves in many ways.

We also tested such things as extraction of hexane extracted soybean flakes with alcohol. This removed most of the carbohydrate, most of the color, and practically all of the beany taste. We found this material still had to be heated in order to improve its nutritional value.

Our extracted proteins were of little value from a nutritional point of view because our extraction procedures were too alkaline and our regular precipitating agent was sulfur dioxide. We were not able to show that heat had any effect on our isolates in those days but in recent years much better products have been produced which are improved by heating in the presence of moisture.

From this example, we might draw up another requirement for our flour. It must be simply and cheaply produced.

To condense this talk into a few words, we can say that the six requirements of a flour for human food are:

1. It must have no flavor or a pleasant flavor.
2. It must have a pleasing texture or mouth feel.
3. It should have a light color.
4. The nutritional qualities have to be known.
5. Functional properties must be known.
6. It must be simply and cheaply produced.

Any time any of you produce a cottonseed flour that meets all of these requirements, please call me long distance--collect. I want to be your first customer.

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DISCUSSION

Question: Can you describe the cottonseed flour you referred to in the early part of your talk?

J. L. Gabby: I think the only way I can describe it very effectively is to refer you to a person who calls on us, in the Laboratory up in Evansville, Ind., Bill Bodecker. The flour we were using was one that his company, Trader Oil Co., produces. So far as I know, it is the only cottonseed flour on the market in the United States today. Perhaps there are others.

Question: You haven't tried any of the flours produced at the Southern Division?

J. L. Gabby: No, we haven't. Is it commercially available flour?

Comment: A product very similar to ours is commercially available.

Question: Does the alcohol extraction impart any desirable properties to the flour produced?

J. L. Gabby: In soy, it definitely causes some very definite effects that happen to make it desirable for some particular cases. It affects the physical qualities of our soy.

Question: Is this a 100 percent alcohol or a mixture?

J. L. Gabby: No, it can be varied. Back in the days when I was doing it, we used just 95 percent ethyl alcohol. It can be other alcohols. I am sure you are all familiar with the literature on that. It can be others.

Question: Have you examined the protein efficiency of dry beans as compared to chick beans?

J. L. Gabby: No, I can't say that I have. I live close enough to Kentucky that I think it must be pretty good. We have a woman working in the laboratory who makes some of the finest dishes I have ever tasted out of beans and a little chunk of pork.

Question: Do you have any idea what happens chemically or physically to your soybeans on heating? Why do you get this improved quality?

J. L. Gabby: I'd prefer that Dr. Altschul answer that question. I am afraid it might take him quite a little while. There are apparently lots of things that take place on the heating of soy. There are some things that are destroyed, urease and other enzymes; Liener of Minneapolis has published many papers on that particular subject. As a food nutritionist, we really don't worry too much about what they are. We are looking at the end result of what we can do with them in making food products, so I am a little bit at a disadvantage here. I know what happens to soy that I want to use in a product, but all of the things that happen inside, that's another story.

EXPERIENCES WITH FOOD PRODUCTS CONTAINING COTTONSEED PROTEIN CONCENTRATES

by
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Institute of Nutrition of Central America and Panama (INCAP)

Since the appearance of the monograph on kwashiorkor in Africa by Brock and Autret in 1952 (4), there has been worldwide interest in the syndrome. It soon became evident that this condition was the same as that which had been previously described in many other regions of the world under a variety of different names. Subsequent reports and international conferences have confirmed its high prevalence in most of the tropical and subtropical areas (5). It has also been demonstrated that kwashiorkor is primarily due to a severe protein deficiency.

Because of its dramatic nature, kwashiorkor was instrumental in calling to the attention of nutritionists and public health workers, the importance of protein deficiency of which this acute clinical syndrome is only a small part. It has been demonstrated that, in the areas where kwashiorkor occurs, protein malnutrition in some degree is almost universal in the preschool population. More recently, the importance of this nutritional deficiency in older children and adults has become evident. Protein deficiency is indeed very closely associated with socio-economic underdevelopment.

Although it is customarily considered to be a consequence of this condition, it would be much more useful to realize and emphasize the importance of protein malnutrition as one of the major causes for low socio-economic development.

Protein malnutrition, acting synergistically with a high prevalence of infectious diseases, is in fact responsible for high morbidity and mortality rates and inadequate growth and development of children, as well as for the lower productive capacity of adult populations. The consequences are relatively high expenses in medical care, both by the populations and their governments, who have very limited budgets, and significant losses in terms of human resources and potentiality. Malnutrition in the underdeveloped countries, where protein deficiency is the most frequent and important component, is therefore one of the chains in the vicious circle of disease, poverty, and ignorance.

Availability of dietary sources of protein is one of the important factors in the epidemiology of protein malnutrition. Among other factors are low purchasing power of the populations and food habits which further limit the consumption of some available sources of protein to the population groups in greatest need of this important nutrient.

The utilization of protein-rich foods, available as surplus from the more privileged countries, presents many problems and can only be considered as a transitory, palliative measure in any case. In those countries where protein malnutrition is prevalent, an enormous increase in the local production and availability of dietary sources of protein is therefore badly needed. How can this be achieved? I would like to analyze first the present situation and the changes which have occurred in recent years with regard to food production and availability. I am going to use the area of Central America as an example because I am much more familiar with the situation there. We also believe that the nutritional problems there are no greater than in most of the tropical and subtropical areas where a deficiency of dietary protein occurs.

Figure 1 shows the availability of the basic food crops in grams per person per day for the years 1950 and 1962. The figures for corn, rice, beans, and milk are based on total production, no corrections having been

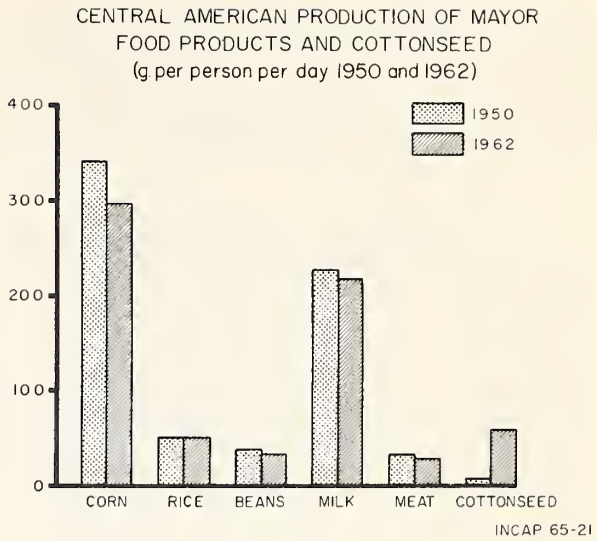

Figure 1

made for importation, exportation, and other uses because no significant changes occurred during the period. However, for meat, the calculation of the availability for 1962 did eliminate the amount which was exported. Though there has been an increase in meat production, this has been mainly for export and the net result has been a reduced availability since 1950, as in the case of the other products.

For comparison, I have also included the availability of cottonseed for the same years and this shows a contrasting enormous increase.

The task of increasing the production of dietary sources of good quality protein, with the urgency needed to correct this situation, becomes seemingly impossible in the light of this declining availability of the basic food crops. The vertiginous rate of population growth makes the prognosis even more somber.

On the other hand, the changes which have occurred in the production of cash crops are quite different. Cotton is one of those which has been shown. Strong economic forces are, of course, behind the expanding production of cash crops. However, we should recognize that a great proportion of the population, the one in greatest need, does not benefit significantly from this situation. As a matter of fact, this change is one of the major reasons for the deterioration or, at least, the insufficient increase in food production.

It is obvious, however, that this production of cotton could make available significant amounts of its protein-rich seed. It is precisely this availability of proteins in areas populated by protein-starved people that has been very appropriately called the "protein paradox." (1)

The problems involved in seeking a solution to this paradox are many and varied. The first one is of a cultural nature. Cottonseed is not now known as a human food. It may be argued that the classification of a product as a human food is in many cases arbitrary. Products which may be highly acceptable by some cultural groups are absolutely rejected by others, but the classification has been established in each case by tradition, which in turn derives from the needs, opportunities, and experiences, and once established, it forms a very strong component of the culture. Cottonseed so far has not been accepted as a human food by any culture. Furthermore, the fact that it has been utilized as an animal feed and that it is considered to be an industrial byproduct, aggravates the problem even more. It is for these reasons that even highly educated and experienced public health workers, although recognizing the need for protein-rich foods, have questioned the utilization of cottonseed as a human food. This is the place, therefore, for food technology to help in solving the problem. Cottonseed cannot be used as such by the consumers, not only for the reasons discussed, but for others which are obvious to this audience. It has to be used, therefore, in industrialized products, and this gives the opportunity for processing it in such a way as to be acceptable by the population for which it is intended. In other words, in a form suitable to the cultural food practices and beliefs of the consumers.

The only characteristic of a properly processed cottonseed flour, which may present some problems from the point of view of acceptability, is its color. This is not a very serious one, but in general a flour to be used as such, or as a component of other foods, is more readily accepted when it is white. Whiteness in most cultures is considered as indicative of "purity" and better quality. The depigmentation of cottonseed flour, if it can be done without damaging its nutritive value would, therefore, be most helpful. The flavor of cottonseed flour presents, in our opinion, no significant problem. If it is not acceptable as such by a given population group, it is neutral enough to be easily blended with other flavors.

The industrialization, which is needed and which can help in solving the problem of acceptability, presents, on the other hand, some disadvantages. In many areas where protein-rich foods are most needed and where cottonseed or similar products could be utilized, industrially processed foods are limited in use and not generally familiar to consumers. The populations living in such areas are still largely dependent on foods obtained by themselves, through subsistence agriculture, or other means, and processed at home. Their economy may be such that they do not acquire sufficient cash to buy industrialized foods, regardless of price. Without an adequate market, there is no efficient large-scale industry with proper distribution and promotion systems that are needed for food products intended for large population groups of low income. Development of such industrialization must be based on a large volume of sales and a low unit profit margin. The present situation of most of the technically underdeveloped countries of the world, moving rapidly toward an industrialized socio-economic structure, including urbanization, offers some prospects that food industries of this type will develop in the not too distant future. We strongly believe that, in spite of its difficulties, any solid long-term program for making available to the population in need protein-rich foods based on cottonseed or similar products, must be based on a sound private enterprise system operating within a free democratic society. Free distribution of such products by governments or other agencies, or subsidies to industry, should only be considered as emergency or palliative measures. In fact this approach, if extensively followed, could hamper a sound development of low-cost protein-rich products.

The better-off countries can help the others in this endeavor by providing them with their experience and know-how and when needed, the initial capital investment to stimulate industry.

The other problems related to the use of cottonseed in human foods are of a technical nature. The most important of these, such as the nutritive protein value of the flours, related mainly to the content of available lysine and the presence of the toxic pigment gossypol have, fortunately, been solved or are well on

the way to solution. These are problems receiving the attention of this Clinic, being discussed by better qualified persons and, therefore, I will not analyze them.

It will probably be more indicated for me to review now very briefly the experience of the Institute of Nutrition of Central America and Panama (INCAP) in the development and promotion of cottonseed-based protein supplements for human feeding.

The purpose of our program was to develop a food which would be adaptable to the eating habits of the population, within their economic capacity, convenient for transportation and preservation, easily prepared under the local conditions and nutritionally adequate to supplement the regular diets with the needed protein; and, if possible, to provide the other essential nutrients deficient in the local diet.

Different flours cooked with water as a gruel are very commonly used in the area for the feeding of small children, particularly as a substitute for milk during and after weaning. This practice is one of the major dietary factors responsible for protein malnutrition, because the flours commonly used are either corn or rice. The use of corn or yuca (cassava) starch in such drinks is, of course, even worse. This practice indicated, therefore, the desirability of developing the protein supplement as a flour, making it as similar as possible to those already being widely used and recommending its use in a similar way.

This type of preparation would have the additional advantage of reducing the industrial process to a minimum, which was very desirable for economic reasons.

The fundamental idea was to use a cereal flour as the basis, supplemented with a protein concentrate to improve both the concentration and biological value of the product's total protein. From the beginning it was also considered desirable to add to the mixture, if this proved to be practical, adequate sources of vitamins and minerals. Vitamin A and riboflavin were of particular interest because they are usually deficient in the local diets and the mixture under study was designed to be used when milk, a natural source of these vitamins, was not available. For this last reason, it was also considered necessary to assure that the mixture had an adequate calcium content.

In 1956 a mixture was developed in accordance with this principle which passed all the laboratory tests as well as the very strict assays of its nutritive value in experimental animals. It was known in the laboratories as "vegetable mixture No. 8" (8). Its formula is shown below:

Formula of Vegetable Mixture INCAP No. 8

	Per 100 g.
Corn "Masa" flour	50 g.
Sesame flour	35 g.
Cottonseed flour	9 g.
Torula yeast	3 g.
Dehydrated kikuyu flour	3 g.

Incap 65-25

The corn "masa" flour is obtained from corn which has previously been cooked with lime, as is customary in the area for the preparation of tortillas. This preparation of corn was chosen because previous studies indicated that it had some nutritive advantages over corn not subjected to this treatment. This preparation also provided a suitable amount of calcium. The sesame flour and cottonseed flour provided the protein which, when combined with that of the corn in the proportions contained in the mixture, resulted in a protein of adequate biological value in a desirable concentration. The use of a larger proportion of sesame flour than of cottonseed flour was based on two factors. First, sesame was the main seed used in the oil industry. Secondly, the then prevailing concept regarding the danger of using too great a proportion of cottonseed due to possible gossypol toxicity. The torula yeast was added as a source of B complex vitamins, particularly riboflavin. The kikuyu is a common grass which had previously been studied and was known to be an excellent source of carotene.

Mixture No. 8 was then subjected to clinical evaluation with children (7). For this purpose normal preschool age children, kept under close hospital supervision, were first given the mixture cooked with water and sugar as a gruel once or twice a day to check its acceptability and tolerance by the children. When enough satisfactory experience had been obtained, the mixture was again given to normal children, but this time as the only source of protein. Several children were kept on this diet for as long as 3 to 4 mos. They continued to gain weight normally,

were happy and active, and showed no clinical or biochemical abnormalities. Nitrogen balance studies were carried out in children fed the mixture as the only source of protein. Milk was used as a control, the diets in both cases providing 2 to 3 g. of protein per kg. of body weight per day, as well as adequate amounts of calories and all other essential nutrients. The results showed no significant differences in the nitrogen retained when either the mixture or milk were used, as shown in table 1.

Table 1. --Comparison of Vegetable Mixture 8 and Milk in Young Children

Protein intake (g./kg.)	Milk Absorption % of intake	Retention % of intake
	Milk	
2.8	81	20.5
	Vegetable mixture 8	
3.0	72	19.1

Incap 65-23

Finally, and for the purpose of testing further the value of the mixture as a source of protein, it was used in the treatment of children with protein malnutrition. Cases of kwashiorkor were then treated with mixture No. 8 as the only protein source. The results, when compared to those obtained with milk, were different only in that edema disappeared a little later, and the serum albumin increased to normal levels at a slower rate. The final result was equally satisfactory, as illustrated in figure 2.

Figure 2

By the time we had completed the mixture No. 8 tests, an important change had occurred in relation to the availability of its ingredients. Cotton production had increased to the extent where it had displaced sesame in the oil seed industry. Sesame meal, an important ingredient in the formula was, therefore, not commercially available. Fortunately, sufficient information had been developed on cottonseed flour, particularly in regard to the limits of tolerance of gossypol and on other factors affecting its nutritive value, to make it possible to formulate mixture No. 9, using cottonseed flour as the protein concentrate in place of the sesame (3). Mixture No. 9 has the composition shown below:

Formula of Vegetable Mixture INCAP No. 9

	Per 100 g.
Corn "Masa" flour	28 g.
Sorghum "masa" flour	28 g.
Cottonseed Flour	38 g.
Torula yeast	3 g.
Dehydrated kikuyu flour	3 g.

Incap 65-24

Sorghum "masa" is prepared in the same way as indicated for corn "masa" and was used to reduce the cost while at the same time maintaining the nutritive and organoleptic characteristics of the product. The other ingredients were the same as indicated for mixture No. 8.

This formula was submitted to even more extensive biological assays than mixture No. 8 (2). For the animal assays rats, chickens, pigs, and dogs were used for both growth and metabolic studies. All the information indicated that both mixtures had about the same biological value. The nitrogen balance studies in children were also equally satisfactory, as shown in table 2. In this case milk was also used for comparison, but with varying levels

Table 2. --Comparison of Vegetable Mixture 9 and Milk in Young Children

	Milk		Vegetable mixture 9	
Protein (gm./kg.)	Absorption % of intake	Retention % of intake	Absorption % of intake	Retention % of intake
>-4.0	84.4	22.0	66.1	24.1
3.0-3.9	84.9	17.1	70.2	16.8
2.0-2.9	82.6	16.3	68.9	17.8
1.0-1.9	78.1	24.9	66.2	15.2
<-1.0	67.2	8.1	59.1	4.5

Incap 65-22

of protein intake. It can be seen from this table that, at adequate levels of protein intake, there is no difference in the nitrogen retained either from milk or mixture No. 9. Only when the intake was below 2 g. per kg. of body weight per day, which is considered insufficient for children of this age, did a difference appear which favors milk (7).

The ultimate objective of these studies was to provide a suitable product to be used by the general population as a regular food. Thus far, information had been obtained on its nutritive value and on its acceptability by small children under hospital conditions. Therefore, the next step was to determine its acceptability by the potential consumers. With the cooperation of the Department of Nutrition and some health centers of the Ministry of Health of Guatemala, the mixture was distributed to mothers of preschool age children regularly attending health centers located in four different regions of Guatemala. Demonstrations of the product's preparation and use of the product were given to the participants and this was checked in the homes by visiting nurses. It was found that during the period of the test, which varied from 15 to 19 wk. in the 4 localities 65 to 92 percent of the children to whom the mixture was offered liked it and consumed it regularly throughout the period of the acceptability test (6).

The next step was its industrial production and commercial distribution. For that purpose some changes in the formula were first introduced. It was found that the dehydrated kikuyu flour was difficult to produce locally on a large scale and that its preparation had to be well-controlled to prevent the destruction of the carotene. For this reason it was found to be more convenient, both from the economical and nutritional point of view, to replace this product with synthetic vitamin A. A further manufacturing economy was the use of crude corn or sorghum flour instead of the specially processed "masa" preparations. Calcium could then be provided as calcium carbonate added to the formula. These modifications resulted in mixture No. 9A, having the composition shown below:

Formula of Vegetable Mixture INCAP No. 9A

	Per 100 g.
Corn flour	29 g.
Sorghum flour	29 g.
Cottonseed flour	38 g.
Torula yeast	3 g.
Calcium carbonate	1 g.
Vitamin A	4, 500 I. U.
	Incap 65-27

This mixture contains 27. 5 percent protein of adequate biological value and provides all the other essential nutrients except vitamin C. Its caloric content is low because it was designed primarily as a protein supplement. Further clinical tests showed that 75 g. of this mixture would correct the prevalent deficiencies of the regular diet of preschool age children of the area and could be prepared in the form of three or four glasses of the popular "atole" (maize gruel).

For the commercial distribution of the product, a trade name was then necessary and, Incaparina, from INCAP and harina (meaning flour in Spanish), was chosen. It was further decided to use Incaparina as a generic name for all vegetable mixtures developed by the Institute for human consumption and containing at least 25 percent of protein of high biological value.

This research brought the product to the stage for commercial development in 1959. In cooperation with a commercial firm and the Ministry of Health, the initial Guatemalan market test was undertaken in that year and the results were encouraging. The pioneering work in Guatemala served to establish the principles which have been followed in working out arrangements between INCAP and qualified food industry companies for the commercial application of the product in several other countries. In this mutual effort, we work closely with each of the producers in the adaptation of the original formula to the varying raw material situations, food habits, and other local factors. For example, in Colombia a formula, No. 15, in which soya flour replaces half of the cottonseed flour has been found to be both economically practical and acceptable.

INCAP has granted authorizations to produce and distribute Incaparina to six companies in as many Latin American countries. Negotiations are now in the final stages to include 2 more countries with additional markets under study. Sales in Guatemala, where the product went on the market in 1961, have averaged about 50 tons per month during the last 6 months. A sales volume increase of 160 percent during 1964 over 1963 tends to confirm the product's continuing acceptability in Guatemala where the current consumption represents sufficient daily rations for 25, 000 children. In Colombia, Incaparina was launched nationally late last year and production facilities are in operation with a capacity

of 200 tons per month. The producers' sales projection for 1965 is in excess of 2,000 tons. Plans for the commercial introduction of the product are now well advanced in Venezuela, Panama, and Brazil, and active consideration is being given to a Central American Common Market program, as well as projects in other Latin American markets.

Price is, of course, a most important factor in the economics of a low-cost protein-rich product of this type. Our approach has been to base the price to the consumer on a very high volume operation with a reasonable return to the producer. In any event the price must have a very favorable relationship to milk or other animal sources of protein. For example, the 500 g. or pound package is sold at retail in Colombia for 11¢ in terms of the U. S. Dollar. This is about 1/2¢ per glass of the prepared drink and is 6 times less costly than milk in the local market.

Total Incaparina production during 1964 exceeded the 2 million lb. mark, an increase of 340 percent over the previous year. With new programs coming to maturity in several large markets, a further increase should be expected this year. Potential markets for Incaparina are also being studied in Africa and elsewhere outside of Latin America.

We are all conscious of and very much concerned about the appropriately called "population explosion," I believe that, at least for some areas, very drastic measures are needed to control this serious problem. However, I also believe that we, public health workers, nutritionists, food scientists, and technologists must contribute in a positive way toward a better utilization of the resources we have to solve the present shortage of food and, thus, to prevent an even further deterioration as the population increases. The correction of the food shortage is fundamental if humanity is going to live in peace and harmony, every man having the possibility of satisfying his basic needs. This is, therefore, a great challenge and an urgent must for science and industry.

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DISCUSSION

Question: Doctor, is there any explanation why the protein quality of Incaparina is lower when compared to milk at low levels of protein intake? Have you been able to find out the reason for that?

Moisés Béhar: Yes, it is very well known that to test the quality of a protein you must work at levels of protein intake below requirements. When tests are carried out above the requirements, two proteins with different biological value can give similar results. Below the protein requirements, the test becomes much more sensitive. In this case, it indicates that though the protein mixture is not really as good as milk, if you consume enough, you may get as good results as with milk. I don't know if this is clear, but the important thing is that at low levels of intake, the test is much more sensitive.

Question: But you don't know why the test is much more sensitive?

Moisés Béhar: Well, because the organisms will utilize the protein much more efficiently at low levels of protein intake. If they are essential amino acids which are limiting the biological value of the protein because of its low concentration, this will become apparent at the lower levels. On the other hand, if there is some excess of protein, then the deficiencies would not show.

Question: I am wondering, Dr. Béhar, if the rate of growth of the long bones has been used as a means of evaluating these proteins.

Moisés Béhar: Yes, we have a study that just finished about 6 mo. ago, in which during 5 yr. we were supplementing the diet of all the children of a small village with this mixture, and comparing the performance of those children in terms of their general health, and growth with that of other similar children. One of the tests regularly done was to X-ray the wrist every 6 mo. This is one of the most sensitive tests we have found in studying these different populations of children. We have found a very different growth rate in the bones of those whose diets are supplemented as compared with those whose diets are not supplemented.

Question: Are the Incaparina diets in liquid form or solid?

Moisés Béhar: It is sold as a flour with instructions as to how it is to be used. The most common way of preparing it is to add it to water with some sugar or any flavoring and cook it till it thickens slightly. This is similar to a popular drink called "atole," which is what most mothers give their children in the weaning and postweaning period, except that they use cornstarch to make "atole." We recommend the use of this flour which is 27 percent protein instead of regular starch, but it can also be introduced in other ways. We have prepared a small book of recipes, suggesting that this flour can be used as any other flour for preparing cookies or soups and a great variety of dishes, as it is recommended for the whole family and not just for the small child.

Question: Was there a gossypol analysis made on the cottonseed flour in the mixture No. 9?

Moisés Béhar: Yes, we are very, very careful. In the arrangement with the producers, we analyze in our laboratories the raw materials, as well as the final products, regularly, and we adhere very strictly to the limits that have been established by the Protein Advisory Group of the United Nations in terms of the amounts permitted of gossypol, both total and free.

FACETS OF OIL MILLING IN SOUTH AFRICA

by
W. G. Hancock
Epic Oil Mills, Limited

Mr. Chairman and ladies and gentlemen, I would first like to say how honored I feel to have the opportunity of addressing this Cottonseed Clinic.

I would also like to say that I hope the penalties for false pretenses are not very serious in the United States since I am sure that your reaction is that I am South African, that I have been for a considerable time in the oil industry and at any rate when I came here to the United States that I knew something about cottonseed processing. Well, I have to plead guilty and to admit that none of them are

true. I went to South Africa nearly 7 years ago from Great Britain and joined the edible and fatty industry just 6 years ago. When I arrived here, I realized that I knew nothing and that we in South Africa know nothing about cottonseed processing. But I feel that everybody has been so kind to me, the least I can do is to give you some information of South African conditions, and I hope that you will not be bored if I first consider the geography, the history, and the present industrial state of South Africa before I deal with any of my personal reasons for being here.

Could I have the map, please, sir? I looked up this map because I found that the geography of South Africa does not seem to be very well known here. This shows the Republic of South Africa, and you will see that it consists of four provinces. The big green one in the lower left, the Cape of Good Hope, the red one on the right side, which is Natal, the Orange Free State slightly inland and the Transvaal, the yellow one. South Africa has certain areas of self government, and of course a central administration. It also administers Southwest Africa, a German possession in 1914, under a League of Nations mandate. You will also notice that included in South Africa, although one of them is very difficult to see, there are some British protectorates, Swaziland right up in the right-hand corner and Basutoland on the right-hand side slightly nearer the center. On its northern territory, it is bounded by Bachuanaland which is a British protectorate. Further north you can see Southern Rhodesia. There is a part just northeast of Africa generally known as Mozambique.

A great portion of South Africa is a high plateau. In the upper portion you can see Johannesburg, which is a few feet under 6,000 ft. above sea level with a narrow coastal plain. The country is highest at the east end and gradually slopes to the west. As a result, two main rivers--which unfortunately are not shown on the map--the Orange and the Vaal, flow east to west eventually reaching the Atlantic Ocean in Southwest Africa as one river.

Climatically, the country is pleasant and invigorating, having a few of the sharp variations which you usually get in northern areas at the same latitude. The average sunshine per day varies between 7-1/2 to 9 hrs. with an average rainfall of 17-1/2 in. Only about one-fourth of the country receives more than 25 in., and this is generally concentrated in the summer--6 mos. usually falling as heavy thunderstorms. As a result, very large areas are completely unpredictable in rainfall being subjected to recurring drought and floods. As a result, agriculture is limited to those areas in the coastal plain where rain is assumed or where water can be obtained from the rivers draining from the escapement or in those areas mainly on the east of the plateau where rainfall is more or less assured or general--the total area is only about 15 percent of the country. Water conservation is, therefore, important and is being tackled vigorously with financial aid to farmers to build their own dams and by government control of rivers. One very large scheme is just commencing.

Historically, Cape Town was the first settlement in South Africa. It was first settled in 1652 by the Dutch in order to give a source of fresh water and food to the ships of the Dutch East India Company sailing to the Dutch East Indies. Later, this developed under a full settlement, and the population was increased by the French Huguenots. Natal was settled later by the British, and during the Napoleanic wars, the Cape area was taken over by the British. During this period, expansion had taken place northeastward to be met by an expansion of the Bantu peoples southwards.

In the 1830's, we had the period of the Great Trek when the original Dutch-French population moved northeastwards and formed several republics which eventually became consolidated into the Orange Free State and the Transvaal. However, gold and diamonds changed all this, particularly gold on the Witwatersrand where Johannesburg now stands. Witwatersrand means the ridge of the white waters, and in common with most of the area of South Africa was agricultural, but the allure of the gold changed the area. There was a large influx of population that came into the country.

It is too difficult to go into the sources, the why and wherefore of the South African War which occurred in 1899 to 1902, but by the Act of Union in 1910, South Africa became one country, the four provinces being consolidated into the union. The self-governing dominion in the British colony in 1961 became the South African Republic. Industrialization was mainly dependent on the gold mining industry. It started in the 1920's and has

made great strides, particularly after 1945, since the country, after its experience in the 1939-45 war realized that it could not depend on outside sources, particularly if another similar debacle occurred as in the 1914-1918 and the 1939-45 wars. Fortunately, this industrialization has tended to become centralized around Johannesburg and Durbin. I think you will realize that you would probably have to come to a country like the United States to see a similar sort of development over a similar short period.

The company by which I am employed is about the fourth largest outside of the mining group. It has many wide ramifications but its interests lie mainly in flour and maize milling, the baking industry, and in livestock feeding stuffs. Epic Oil Mills is interlocked in this big complex. It produces salad oils and manufactures edible fats, including margarine. Its source of vegetable oils is obtained by screw presses and extraction and comes mainly from sunflower and ground nuts, or peanuts as I believe I should call it here, with some maize germ.

We are now commencing to add cottonseed oil to our output. Sunflower nuts and ground nuts are purchased by a government established organization, the Oilseed Control Board. It is from this organization that we purchase our oil-bearing seeds. So far, cotton has not come into the orbit of this Board.

We have had a fair amount of aflatoxin infection recently in our peanuts, and as I said this morning, we have been working cooperatively among government organizations who are interested and the industry.

Now, I think we'd better pass on to cotton, and I know nothing at all about cotton fiber. I have to fall back on information which I have obtained from one of the directors of an associated company of ours which controls about 70 percent of the ginning operations in South Africa. I hope you will forgive me it I make mistakes. The annual cotton crop has been in the order of 50,000 bales, with the highest crop about 55,000. This growing season, not yet harvested, is expected to reach 80,000 bales provided the good rain is maintained. It is hoped if world prices are maintained at their existing levels, that in 10 years the crop will balance the then existing demand at about 250,000 bales, but this will naturally depend on the extension of irrigation and the competition of other crops.

Very little has been done with new seed or seed breedings since the Empire Cotton Growing Corporation left South Africa in 1938-39. All the cotton is handpicked, and it has a staple of 1-1/16 to 1-1/8 in., but a little of a shorter staple cotton is produced, about 31/32 to 1 in. for which a considerable demand exists and all of which is imported. Yields of cotton are between two bales per acre on irrigated areas down to one-third of a bale on rain-grown areas. Pest control is not practiced on the rain-grown areas, but commonly practiced in irrigated areas.

Having gotten the seed, we now reach the area of my interest and the reason for my trip. We reached the conclusion that our handling of cotton seed was unsatisfactory. How unsatisfactory it was I had no conception until I came here and saw the system in efficient operation. It is so bad that I refrain from quoting any of our figures.

It is here that I would like to say, to as wide a public as I am likely to have the opportunity of reaching, how much I personally appreciate the enormous amount of help given me by those government and industry members with whom I have come in contact, the result of which I shall return to South Africa much more knowledgeable than when I arrived. I hope that as a result of this Clinic, to which I was invited by the kindness of the Department of Agriculture, I will receive much more information and also have the opportunity for private discussion with experts. I am sure you were informed by Mr. Hinds, who was here from South Africa last year, protein deficiency is a problem in Africa, and you can see that a further supply of vegetable protein such as cotton would be of enormous value to my company in view of our association with an animal feeding company.

Be assured that we in South Africa are most grateful to the cottonseed industry in the United States. May I say that if any of you come to South Africa, please come to Johannesburg, and we will see that you see something of the South African way of life. I would like to say how honored I feel in being invited to speak to you and to thank all of you once again.

DISCUSSION

Question: I am interested in knowing what type of mill they operate in South Africa.

W. G. Hancock: Our mill has four Anderson screw presses and a DeSmet extractor. Of

the other plants that I know of in South Africa, there is one more DeSmet in operation, one more going in. There are two of the Anderson immersion type extractors. Nearly all of the screw presses used in South Africa are Andersons.

Question: What kind of solvent is used in those extraction plants?

W. G. Hancock: Hexane. Fortunately, there are sources of petroleum outside South Africa. One of the things we do not have is petroleum, and we can buy hexane quite easily.

THIRD SESSION

J. W. Kidd, Chairman

PANEL DISCUSSION ON OPTIMUM CONVERSION OF COTTONSEED TO OIL AND MEAL

J. W. Kidd: We are now going to collect the question cards. Are there any other questions to come to the table? If not, we will commence with these. Harold, the first one is addressed to you.

Question: In purchasing cottonseed meal, what specifications or limitations, if any, do you or your firm place on such characteristics as nitrogen solubility, available lysine or free gossypol content?

H. L. Wilcke: These specs that we put on the cottonseed meals include the protein and fiber. In the case of meals that are to be used in the ration of the laying hen, we do put a free gossypol specification on it. We do not use nitrogen solubility as a spec, but we do let our preference be known, and the same applies for available lysine.

These things are all part of the total value of the product that I mentioned, and when you consider all of them, with the exception of the free gossypol for the laying hen, the sum of these is going to represent the value of that product to us. For instance we aren't necessarily going to turn a product down if it doesn't meet the desired level of available lysine, because we can supply that by other means if the product is good in other respects.

Question: Of what value would a cottonseed meal of 50 percent protein, 4 percent fat, 8 percent fiber, and 4 percent moisture be compared to 50 percent protein soybean meal (solvent) with low fat?

H. L. Wilcke: This is a figure that is going to vary. As I told you, it is not a simple substitution, and so the relative value of the two is going to depend upon the price of some of the other ingredients as well as these two alone. In addition, it's going to vary with the use to which it's to be put. For instance the product you are speaking of would be used for the laying hen because lysine is not quite as critical for that mature animal; it might not be used for the growing animal, where lysine is more critical. I am sorry we can't give you a definite dollar figure, any more than we can tell the producers of lysine what their product is worth, or than we can tell the soybean people what the differential has to be between 44 percent and 50 percent meal. You will find this type of product used in some areas whereas in other areas it is not considered from the standpoint of cost.

Question: When the machine comes up with a 30 percent alfalfa meal ration and it meets other criteria, why isn't it used?

H. L. Wilcke: For one thing, alfalfa meal is not one of the most palatable ingredients in the world; for some purposes, you'd be above your limit in fiber as well.

J. W. Kidd: Thank you, Harold. Next, I have one here for Charles Hay.

Question: Is the formation of moisture balls in the DT (Desolventizer-Toaster) unit a serious problem? Can a separate agitator be used to break up these balls?

Charles Hay: Well, it can be a very serious problem, but with the proper distribution of the sparge steam in the DT, I think this can pretty well be eliminated. If you use the sparge steam to sweep, where it contacts all of the meal rather than just blowing it in through the side of the kettle, you can by

uniform distribution pretty well eliminate moisture balls.

Question: What would you say the optimum conditions should be in the conditioner for direct solvent extraction?

Charles Hay: This is a little bit out of my field. All I can tell you is what I have seen at some of the various mills. We don't have complete direct extraction at present. We are working on one. The optimum conditions in the conditioner for direct solvent, as we have been told, are to go in at around 125 deg. in the top ring and come out around 160 to 175 deg., with about 8- to 10-percent moisture. I am not sure of that. Maybe someone else could enlighten you better on that.

J. W. Kidd: We have a question here for Mr. Easley.

Question: Please comment on the importance of rolling.

O. D. Easley: About the only information I can give you to that is we have three sets of 60-in. rolls, and a couple of years ago we had some shaft trouble on one set; once that roll was out, we ran tonnage through two sets of rolls and our refining suffered pretty badly in color and loss. I am convinced that adequate rolling is even more important to screw press operation in refining loss than it is to extraction. I could be in error on that, but that is my belief.

Question: Would you outline your recent experience on cooking capacity, how reducing throughput through your 3-high 85 in. cookers reduced your refining loss in oil some 3 percent?

O. D. Easley: That is going to take a little review. When we installed our pressing equipment in Memphis, we put in 6 super Duo's and 6-high 85 in. cookers which the manufacturer's Engineering Department said was more than adequate.

We have since gone from two 6-high to three 6-high and then to three 7-high cookers. And some years back before we raised our tonnage on this equipment, we averaged for the season 3.5 residual oil, which we thought was good, and 3.7 refining loss, which we knew was darn good. We did this by doing just what I outlined a while ago, an extremely high moisture, moderate temperature cook at top rings, and a fast flash dry. Last year we had some rather dry seed, and towards the end of the year I shut down one press and increased the moisture in the top ring for the dry moisture seed with an immediate drop in extraction of 0.5 oil. We only did this for 6 days, the last car we shipped had dropped 1-1/2 percent refining loss. We didn't run it long enough to get any conclusions on refining loss. I was trying to see what it would do on extraction.

J. W. Kidd: The next question is directed to Mr. Tennent.

Question: What is the nature of the analysis of the composite seed sample for pesticide residue?

J. L. Tennent: The main thing we are interested in--and when I say "we" I speak of Ralph Woodruff and I--is the residue that might be in the lint or on the hull. If any of the pesticides used in the fields are still in the cottonseed, this information may be of some value to the industry in the future. One other purpose for the analyses is to determine arsenic content. This is something you may not know, that cottonseeds have a trace of arsenic, at times, when grown under certain conditions, in certain areas, and for no reason at all, not having come in contact with pesticides of any kind. This is something amazing to me. But we are mainly interested in the pesticides. We want to be prepared when the question is brought up by the Pure Food and Drug Administration or anyone else who might have something to say about this.

J. W. Kidd: Thank you. Before you leave, let me ask you, do you mean that in cottonseed grown on certain land there is something in the soil that adds this trace of arsenic where there have been no arsenicals used?

J. L. Tennent: That is exactly what I mean. According to our chemists, we have had seed analyzed that we knew had no trace of any chemicals having been used on them other than ammonia in the soil, no pesticides and no insecticides, and I have been told that there is a trace of arsenic in some of them.

Some cottonseed contain a slight trace, but we have any number of analyses that say no trace of arsenic or any other thing.

There is one thing I'd like to refresh Andy Burner on, if I might. If you will remember, Andy, in looking back a few years, we won't say how many, but we were processing with straight extraction in a certain plant, and we bypassed the screw presses. If you will remember, we were flaking and going into the cooker at a very high moisture and leaving this tempering cooker on straight extraction, if you please, at about 180 to 185 deg. with a moisture content of about 9-1/2 to 10 percent, not over 10 percent. This 10 percent was reduced when we changed the screens in the extractor. Do you remember that?

Andy Burner: I'm a little hazy on it.

J. W. Kidd: Harold has a little something to add here.

H. L. Wilcke: I think I should make one other comment on the price of the lower fiber cottonseed meals, and that is that if you want to submit the prices of 41 with a 14 fiber and a lower fiber product at any time at any specific point, we can tell you whether the differential you are asking is too much or not. Now, this seems like it's a pretty indefinite sort of thing, but it's exactly the same thing that the soybean industry went through when they started making 50 percent meals. I think their answer has been that they stay somewhat flexible so that they can put out a 50 or 44, depending on economics, and that is exactly what this kind of thing has to be. It's as simple as "Can I get more for a lower fiber product plus what I can get for the hulls for some other use than I can by taking it out?"

J. W. Kidd: Thank you, Harold. We have a little addenda to you, J. L. It says, "Have you taken into account the presence of arsenic in fertilizer?"

J. L. Tennent: I am told that about the only fertilizer used in about 75 percent of our territory is liquid ammonia. Whether this would have arsenic in it or not, I wouldn't know. There are no sack goods or mixed goods, I am told, that are used very much.

J. W. Kidd: Are there any other questions?

R. A. Phelps: I would like to ask Dr. Wilcke a question about linear programing. Of course, the machine is not going to think for itself, it is only going to use the values you feed to it. Is there a need for more cottonseed data so that you could make better use of the programer?

H. L. Wilcke: At the moment, Dick, I'd say specifically more reliable values on the energy value of cottonseed meals would be one of the most helpful things. In addition, if there are any other specific nutrients in the product, such as vitamin value or something of the kind, that all helps.

R. A. Phelps: Have you used Fred Hill's latest energy data in that programer?

H. L. Wilcke: Yes.

R. A. Phelps: Are you still using any soybean meal?

H. L. Wilcke: A little.

DESIRABLE QUALITIES IN THE PRODUCTION OF MEALS

by
H. L. Wilcke
Ralston Purina Company

The use of cottonseed meal as a source of protein for the ruminant has been well established. Since the ruminant does not appear to be affected by gossypol, within the limits in which we have ever found it in cottonseed, cottonseed meal or cake may be used to meet the protein requirements of the animal with virtually no restrictions. Additionally, the ruminant does require a certain amount of fiber in its daily feed intake and, therefore, the presence of hull is acceptable. Really what we are saying here is that we want the ruminant fed good clean wholesome meals. There is, of course, always the question of the seed that is brought into the plant for processing, but we are taking for granted today in this discussion that we are working with good, high quality starting seed.

The subject for discussion today really, then, is the processing of cottonseed to produce meals which will be used more

extensively in the rations for monogastric animals, specifically the pig and the chicken. Let's start by enumerating uses to which these cottonseed meals will be put in the poultry and swine ration.

First of all, we use them as sources of good, high quality protein. When used for this purpose for the young growing animal, we find that cottonseed protein is very likely to be deficient in the amino acid lysine. The meal, of course, is used to supplement grains, usually corn or the grain sorghums. The grains themselves are notoriously deficient in this particular amino acid as well as some others; and, therefore, the protein supplement must make up this deficiency. This means that the protein supplement used must be considerably higher in the specific amino acid than the chicks requirement, but this is not the case with cottonseed meal. Therefore, when rations using cottonseed meal as the protein supplements are fed to swine or chicks, the first limiting amino acid in the entire ration is usually lysine. This, then, must be supplied by some other protein supplement, such as fish meal or soybean meal, or it must be supplied by synthetic lysine. While the price of the synthetic material is greatly reduced from the prices of some years back, there still is a question of whether this combination of cottonseed meal plus synthetic lysine will provide the protein supplement competitively with those from other sources, such as soybean meal and fish meal, when we consider this deficiency.

As far as processing is concerned, there isn't a great deal we can do about the lysine content except to use as mild processing as possible to keep as much of the lysine available as we possibly can, and not permit the temperature to rise high enough in the expeller and prepress processes to tie up the lysine.

Therefore, the question of the use of the cottonseed meal as the protein supplement becomes one of the economics of the use of cottonseed meal in combination with other protein supplements. Lest this sound too discouraging, we must consider the fact that when soybean meal is used as the protein supplement, the first limiting amino acid is usually methionine. Therefore, from this standpoint alone, the question becomes one of the economics of cottonseed meal plus lysine versus soybean meal.

The second criterion for the use of cottonseed meal in the animal ration is the energy content. We don't ordinarily think of the protein supplement as providing energy also, but when we are using linear programming as we do today, the energy value of a product is considered as well as the protein value. This is an area where cottonseed processors can exert some influence on the final product.

The energy value used for 41-percent cottonseed meal is usually about 56 therms per cwt. This compares with 72 therms per cwt. for 44 percent protein soybean meal and 79 therms per cwt. for 50 percent protein soybean meal. I've given you the values for the two soybean meals because the difference in them comes simply by removing hulls from the 44 percent, which permits the protein to rise to 50 percent. This, of course, is a practice that is common in the oilseed industry. Perhaps I should have said that this represents the failure to add hulls to reduce the protein content from 50 to 44 percent. When we add the soybean hulls back, we are adding a product that has an energy value of about 19 therms per cwt.; but, in the case of the cottonseed hull, we are adding back a product that for nonruminants has an energy value of approximately 0. For that reason, I am considering only 41 percent or higher protein cottonseed meals for this use in nonruminant rations.

The fiber value usually used for the 41 percent cottonseed meal is 14 percent. This can be reduced to at least 8 percent in good manufacturing process and perhaps to a lower level. If this were done, we would have an energy value of approximately 72 therms per cwt. as contrasted to the 56 in the higher fiber product. This puts it on an equal basis with 44 percent soybean meal energywise.

When we are looking at the use of cottonseed meal in animal rations, we are usually comparing it with soybean meal for most Midwestern areas. Looking at the two cottonseed meal is a lower protein product (41 percent versus 44 percent). It is also a lower energy product (56 percent versus 72 percent). Therefore, we cannot make a simple substitution of cottonseed meal for soybean, but the substitution would run something like this: Cottonseed meal plus grain, usually corn, plus another higher protein supplement, such as fishmeal or meat scrap, versus soybean meal as one possible substitution formula; or we could consider the use of cottonseed meal

plus an inedible fat to replace soybean meal plus grain. This latter, of course, would be the more attractive substitution from the standpoint of the use of volume of cottonseed meal and would be the preferred one when economics will permit. That is, it would be the preferred one from the standpoint of the maximum use of cottonseed meal. There would, of course, be a possibility of a straight substitution of cottonseed meal for soybean meal if the energy content of the total ration were permitted to drop and this would be done when economics justified this on the basis of cost of the production of meat from the total ration.

All of this naturally brings up the question of why not add fat to the cottonseed meal, particularly when the prepress solvent method is used and we come up with a fat content of 1 percent or less. This is quite often desirable particularly when the price of fat is low enough to justify this addition. It not only increases the energy content, but it certainly improves the handling qualities of the product as well. However, the fat that is usually the most readily available for this purpose is the addition of soapstock, or we may call them "foots."

Back to the meals. This then gets us back to a problem which I have not mentioned previously, and that is the gossypol content of the product. Some years ago a standard of 0.04 percent gossypol was set as being one that we could live with in using meals for young growing chicks and swine. When free gossypol levels are higher than indicated, the amount of cottonseed meal in the formula would have to be automatically restricted to minimal levels. Therefore, from the nutritional standpoint it would be highly desirable to use fat other than the "foots" or soapstock for the purpose of increasing energy or improving handling qualities.

This point of energy content, of course, is emphasized by the use of machine calculations today. When machine calculations is used, we can utilize much more information on products than we could previously. We not only put in total protein, but we put in the amino acid values for the ingredient and the requirements of the chick, but we also can include energy, the essential minerals, vitamins, and so forth.

All of this means that the values of the ingredients used become much more critical, and they become a matter of total value of the ingredient, a concept that was developed a few years ago by several nutritionists simultaneously. This is the development that has made the energy content of the ingredients one of the criteria that governs the use or nonuse of any specific ingredient at any specific time.

What we are saying, then, is that from a processing standpoint, we would like to have a clean, wholesome product that is as low as possible in fiber; one that has been heated sufficiently to process the product properly but not enough to tie up any more of the lysine or other amino acids than necessary. It should be said here that some of the straight solvent meals have not produced optimum results, probably because of insufficient heating.

One other point that should be mentioned which affects both the protein content and the energy value, which we have been discussing, is the moisture content. This should be kept as low as possible, consistent with good processing practices. When moisture goes up, both protein and energy go down on a percentage basis simply because there's not quite as much meal in each 100 lb. or each ton sold.

I have pointed out all of the discouraging points that I can think of at the moment, and you're probably wondering what you can do to get this material used in the rations for nonruminants. Let me hasten to add that the use of cottonseed meal has definitely increased during the last couple of years. We are getting more meals which meet the specifications that I have listed here, and we are also getting some of the lower fiber products in some areas.

After all, whether we are looking at this particular product or any other ingredient that is used in the production of rations for meat, milk, and eggs today, it comes down to a simple matter of economics. The use of linear programming, which is done by machine calculation, means that after the input of analytical values has been made, the human element or preference for any one particular ingredient is removed. The machine will throw out or bring in ingredients which will supply the desired nutritional factors the most economically. Therefore, we must compete on an economic basis when all is said and done.

While this is not a processing problem, I am convinced that many nutritionists,

particularly those who have been educated in the northern half of the country, are not using as much cottonseed meal as they might. I believe that we have an opportunity today to get more of this type of information into the hands of our universities, particularly. This is a program that your association has been handling very well. We need to get more of these folks actually working with cottonseed meals, feeding them, and seeing results that can be obtained by the proper use of cottonseed meals in animal rations; making sure, of course, that good quality, low fiber, high energy meals are used.

My remarks may have seemed somewhat negative because we're talking today about how we can improve these products. They are not meant to be, but only have been meant to point out some of the areas where we can improve.

SOLVENT EXTRACTION

by
Charles Hay
Anderson, Clayton and Company

My topic today is "Optimum Conversion of Cottonseed to Oil and Meal by Solvent Extraction." I am sure everyone here has been to a sale at one time or another and picked up a bargain. Maybe you bought a shirt, or a suit, or a pair of shoes at half price, and it gave you a good feeling. You were proud of what you bought, proud of yourself for finding the bargain, and proud that you saved some money.

The same thing is true when we achieve optimum conversion. We get a bargain; we get the most out of each dollar spent; and it makes us feel good. Now then, how do we achieve optimum conversion in a solvent plant? We do this by operating at maximum capacity consistent with good extraction, good oil quality, low solvent loss, low maintenance cost, and low labor cost. To be all-inclusive we should add that this must all be done with a good safety record. Strange as it might sound at first, this is not all done in the solvent plant. The most important factors controlling optimum conversion are back in the preparation room. If preparation is not right, it is not possible to achieve optimum conversion. Without proper preparation we cannot get maximum capacity, good extraction, or good oil and meal quality. If poor preparation causes trouble in the solvent plant, we are subject to higher solvent losses, higher maintenance, higher labor, and higher probability of accidents.

Proper preparation, of course, is not the same for all plants, but in general consists of the following:

1. Getting the meats from the separation room to the cooker with a minimum holdup time to prevent FFA (free fatty acid) rise.
2. Good rolling with adequate moisture.
3. Maintaining adequate uniform cooking temperatures and moisture conditions.
4. For prepress, producing a cake with the proper oil and moisture content that will flake or granulate with a minimum amount of fines.
5. For direct extraction, rolling ahead of conditioning is eliminated, but conditioning or cooking takes on more importance. Control of moisture and temperatures is even more critical since 100 percent of the extraction and oil quality are largely dependent on this step and subsequent flaking.
6. Flaking for prepress or direct extraction to produce the proper size and thickness of flake to achieve good drainage and the best extraction. Flake thickness is the controlling factor in the rate of solvent extraction. With free circulation of solvent, the rate at which oil diffuses from a seed particle is directly proportional to the surface area of the particle and inversely proportional to its thickness. Thus, it would seem that an extremely thin flake would be most desirable, but consideration must be given to flake stability, amount of fines, drainage, and so forth, so flake thickness usually is somewhat thicker than the optimum indicated by theoretical studies.

If we have taken proper preparations, 90 percent of our troubles are over. Assuming we have a solvent plant of adequate capacity and can convince the manager that this capacity should not be exceeded, we should then maintain a uniform flow of material to the

extractor. The solvent to the extractor should be heated to approximately 140 deg. F., or just as hot as the incoming feed will allow without flashing the solvent. A solvent flowmeter must be provided so that miscella concentration can be accurately controlled. The extracted meal goes to the desolventizer where we must make sure all the solvent is removed and the moisture reduced to 7 to 10 percent for safe storage. It is in the desolventizer that we make final reductions in free gossypol, and if we do not exercise caution, the protein solubility will be reduced excessively.

Sparge steam should be added uniformly to obtain maximum benefit, and sparingly to prevent darkening of the meal. Final temperature of the meal from the desolventizer will be between 215 deg. and 225 deg. F. in most cases. The meal may then go to a cooler or be pneumatically conveyed in order to reduce temperature and moisture to a safe level for storage. Miscella from the extractor is filtered and pumped at a uniform rate to the evaporator. For added efficiency, the miscella may go through an economizer ahead of the evaporator. This economizer may be heated by vapors from the desolventizer or the evaporator. The evaporator should be operated at the lowest temperature possible consistent with capacity and miscella concentration. The stripping column should also be operated at the lowest possible temperature that will remove the final traces of solvent and moisture below 0.2 percent.

Vacuum on the stripper should be at least 21 in. of mercury and preferably 23 or 25 in. The oil should then go through a cooler before storage to help prevent color reversion. Adequate supplies of low temperature cooling water are absolutely essential for low solvent losses. Surplus condenser capacity is desirable in order to take care of surges in flow or changes in miscella concentration. It is essential to have some type of vent recovery system. This may be cold water condenser, refrigerated water, brine, direct expansion, or carbon absorbers, or mineral oil absorption system. A waste-water evaporator helps remove the last traces of solvent from the decanter waste water, and water scrubbing system. A combustible gas alarm should be provided that will tell us if we are losing solvent in the meal, oil, vents, and waste water. It goes without saying that all leaks should be stopped immediately and that seals and packing glands should be kept tight. Controls should be automatic wherever feasible and should be centered in a master panel for easy visibility.

This properly designed solvent plant can then be operated by one man with part-time assistance for cleanup or filter change. I have heard of a solvent plant that runs without an operator, but I would hesitate to operate this way.

Any properly designed plant operated in the above described fashion should give us optimum conversion.

MECHANICAL EXTRACTION

by
O. D. Easley
Southern Cotton Oil Division
Hunt Foods and Industries, Inc.

When I was asked to participate, I was assigned a certain number of minutes. If I were to review all the various procedures we have tried it would take considerably more time than that. In addition, a presentation by any one operator is necessarily controversial, and any statements made here are my views only.

As a matter of record, I operate V. D. Anderson expellers. I will not attempt to talk on mechanical presses, as such, French screw press or Anderson expellers. Any competent operator can keep equipment in good mechanical condition and get good results on standard press arrangement. The preparation of meats to feed the presses has proven to be the important factor. This we all know. To obtain optimum results with low residual oil, low refining loss, good meal color and odor, requires more preparatory equipment than we believed just a few years back. We now know that we must work high protein through presses for more throughput and less press wear in addition to above desired results. The addition of moisture before rolling is important. Plants with stack cookers, long runs of conveyors or other

mechanical means of adding water to meats with sufficient retention time to penetrate have proven this.

An adequate cook time, with controlled moderate temperatures, at specific levels, I'd say is 175 to 200 deg. in the top ring, fully loaded, according to whether you want low residual oil, low refining loss or a median of both; and approximately 212 to 215 deg. in the second ring, this ring also fully loaded. Then, as a fast flash dry with low meats level and live agitation, at approximately 250 deg. and 3 percent moisture, or the moisture and temperatures your type press requires, retention times of 60 to 70 min. are required. Moisture in the top ring must be kept at a high level, higher than we previously thought.

The addition of this moisture is critical in that it should be as high in the meats as possible to handle through conveying equipment before entering cooker, and still have the capacity to dry down to approximately 12 percent. Any additional water added in top of cooker should be sprayed on the surface of incoming material, with the temperature brought up promptly. This is the critical spot to keep water balls from forming. Cooker gates can be cut down to smaller size and float arms revamped on old-style batch cookers, with plows on sweeps, to provide continuous meats flow at fairly constant level, and very little short cycling. Water balls, batching and short cycling are a rough problem in old cookers with big gates and drag float arms, and will prevent a uniform cook.

All the above requires more preparatory equipment and much more cooking and drying than most plants now have.

As I stated earlier, this is my opinion formed by my experience and information obtained from other operators, and it may be controversial to many of you.

QUALITY CONTROL PROCEDURES

by
J. L. Tennent, Jr.
Delta Products Co.

I am sure that we have all been told the problems that confront our group today, many of them, certainly not all of them, by Drs. Goldblatt, Fahey, Davis, Altschul, Wilcke and each of the others. I would like to tell you how great a privilege it is to attend the Cottonseed Processing Clinic and how happy I am to be here and to take part in this program. There is much to be gained in attending each year.

Quality control procedures are, or can be, a very important part of our operation, as each of us wants the very best products, uniform, with no variation in quality, if at all possible to produce such quality.

I would not attempt to tell you just how you should operate your plant. I will say that we exchange ideas with each other frequently and benefit from these discussions.

To control the quality of our end products we must begin with storage of the seed. After they are stored in houses, tanks, bins, or on the ground, our problem really presents itself. There are many of us here who have equipment designed and installed several years ago, when the cotton harvest lasted from 4 to 6 mo. instead of from 4 to 6 wk. as it does today in many locations. This, of course, presents the problem of high moisture seed having to be stored when years ago we would try to process first and store the drier seed. We have just completed processing a house full of cottonseed in which many tons from 15 to 18 percent moisture content were stored. It is impossible to sleep with both eyes closed, with seed such as these in storage. We have no alternative it seems, except to take temperatures every day if possible. Any heating could mean trouble with the quality of our products.

I am in full agreement that sometimes it may be impossible to prevent some loss of quality in storage. This means therefore, that we must blend the slightly affected seed with those of prime quality and try to produce prime products. This can be costly and cause one to take a look at present seed storage and cooling machinery. We will agree, I am sure, that this must be decided by management at each plant, taking several factors into consideration.

Linters present more problems today than in the past, though we thought we had

many problems several years ago. I have no marketing connections; nor any desire for such, but I feel today the processors and consumers indicate a demand for linters, meal, and oil.

We must try to produce and maintain top quality if we want to keep this business. The product must be uniform. We must keep close scrutiny on the seed feeding from storage to production. The quality of the seed could be changed because of the geographic location from which it is received and the difference, even though slight, could cause discussion with the buyer or consumer. Buyers have different outlets, or course, and demands can be different from plant to plant. With wood taking over certain parts of our outlet, it looks as though this is the second important phase of our quality control. It must have constant attention at all times, and we must maintain uniformity if we expect to hold our own with competition.

After delinting, the next phase is separation. Here, of course, we can affect the quality of our oil and meal. One must be able to decide about protein control and oil and meal quality on very short notice. As each of us knows, hulls can affect oil quality, if protein is corrected before pressing or extracting; though this is not the case every time. The quality of the seed in general will determine whether we shall shoot for exceptionally high protein meal (for oil quality) and reduce (in grinding) with hull bran. Cottonseed stored under normal conditions, an average of 12 to 12-1/2 percent moisture--and reduced in temperature as soon as stored, have been known to rise in FFA for no apparent reason. When these seed were processed, it was necessary to change cooking almost entirely. The acid would continue to rise before the meats reached the mechanical press. From this experience we learned a great deal, and part of it the hard way.

The amount of water used on meats before cooking, and where added, is very critical in oil quality. This can affect the bleach color and refined color as well as refining loss. The FFA can also rise if not brought to 180 deg. or 185 deg. very quickly, under certain moisture conditions. Places where the product being processed could lie dormant and then be moved after some deterioration, must be eliminated. This will definitely affect all end products from the material being processed. This also presents problems in sanitation.

As we follow oil through the process; whether it be hydraulic, mechanical, solvent extraction, or prepress solvent, there are many phases that must be controlled properly. I shall deal directly with prepress. Mechanical presses or expellers must be kept in top shape. The feedback of too many "foots" or meal from the cages can cause great effect on oil quality in FFA rise. Some are using a water-wash in oil from expellers and screw presses. This, if operated properly, helps the quality of the oil, however, there is potential trouble involved if anything goes wrong and remains undetected for only a short time.

In solvent extraction the temperature on evaporator and stripper are very critical to oil quality. The optimum must be maintained or the color can be increased greatly in the oil. When this is the case the refining process can be costly and oftentimes the oil must be refined over and over. There also seems to be a rise in FFA if flakes are not introduced immediately to solvent after prepressing, and we have also checked the acid on oil left in miscella for a 24 hr. shutdown period, and it showed a rise of 0.2 to 0.3 of 1 percent. It is imperative that the oil temperature be reduced as quickly as possible after the filter in prepress and after the stripping process in solvent extraction. We prefer a temperature of not more than 90 deg. F. We are of the opinion that combining the prepress oil and solvent extracted oil is somewhat the best method, but as stated before, both oils should be cooled.

Lysine is something we should all know about. Feeders have found that this has great effect. Possibly in the very near future we may be called upon to do something with lysine in meal at time of processing.

I would be greatly in favor of treatment for all delinted cottonseed having color. This is something that can cause trouble in any product, if not detected. Unless treatment for colored seed is used, it is possible to mix small amounts in a load of seed and possibly slip by the unloading crew. This has been done and seed have had to be reloaded from dump pits to truck and returned to the shipper.

Insecticides are being watched more closely. It is believed by some that this may

have some slight effect on oil color. I have not had experience with this, so I am unable to say either way, but with the tremendous increase in the use of all types of chemicals in the growing of crops, all of us are discovering changes in the cottonseed. For example, we are learning that refining losses are not apparently as closely tied to FFA as we once thought. This may also apply to the refined and bleach color. The point I am trying to make is this. There may be times when we are not always able to produce quite as good end products as the qualitative analysis of the cottonseed would indicate. Just what the answer is, we are not certain, but a search for the solution of this problem should be continually before us. We have seed composited daily and a complete analysis run on these each week for information that could be pertinent in future developments on insecticides, herbicides, and so forth, in processed products.

We now reach a point that, in my opinion, is just as important as any mentioned heretofore. There must be constant discussion between manager and superintendent; and between the superintendent and key personnel. Any suggested changes to improve the quality should be passed in writing to the superintendent, and then on to the various key personnel with initialing required after reading or discussion. The manager is the one in most cases that would know the requirements of the consumer or buyer. A close relationship, regular observation of samples of products, and complete followthrough is most essential.

It is essential to have all cars, tank cars and tank trucks checked very closely before loading the products. In loading oil this is considered especially important. In a rush, a refinery employee could fail to clean a tank car or truck. The next load, and possibly several loads, could be affected by a dirty tank. Foots in a tank car can cause FFA rise within 24 hr. Some plants have seed with a high acid content and settlings in a tank car or truck will immediately reflect in the next sample leaving room for discussion with the second shipper, and doubt on the part of the buyer.

ADVANCES IN COTTONSEED PROCESSING THROUGH RESEARCH OF THE PAST DECADE

by
Edward A. Gastrock
Southern Utilization Research and Development Division

From 9 to 11 billion pounds of cottonseed are produced annually, with a farm value of approximately $250 million. At the consumer level cottonseed products are valued at approximately $1.5 billion, or 6 times the farm value. Processing accounts for an important part of this increase in value.

But processing is motivated by research and advancing technology, both of which add impetus to change. These changes are reflected in the capacity and type of equipment used, in the processing concepts followed, and even in the raw materials handled.

More Capacity, Lower Costs

Larger Mills.--Researches on improving seed varieties, harvesting, and ginning techniques, transportation handling methods, and storage practices have made it possible to accumulate and store successfully adequate quantities of seed to operate up to 12 mo. each year and have contributed greatly to the increase in size of individual mills.

Similarly, the installation of larger pressing and solvent-extraction units can be traced to the research and development activities of equipment manufacturers and others. Examples are screw presses with individual capacities in excess of 100 tons of cottonseed per 24 hr. and producing a lowered residual oil content in the press cake and solvent-extraction installations capable of extracting 800 or more tons of cottonseed per 24 hr. efficiently.

More than one oilseed.--Contributing in some measure to larger mill installations is the ability to handle more than one oilseed. Involved here is research in preparation techniques and the design of versatile equipment and accessories for efficient operation.

Fewer mills.--As the average size of the individual cottonseed oil mill increases, the number of active oil mills tends to decrease. This is accentuated by the tendency of individual mills to increase the length of their operating season, whereas the size of the annual cotton crop only varies roughly between 4.5 and 5.5 million tons.

Processing Trends

Extractor types. --On the basis of recent installations the trend is apparently away from vertical-basket solvent-extraction plants and toward horizontal units. The horizontal extractor provides more flexibility in arranging an efficient extraction cycle with appropriate countercurrent extraction stages. The final drainage of wash solvent and drainage between extraction stages, coupled with displacement washing of miscellas in all stages, are also found favorable in horizontal-basket extraction. Several designs of horizontal baskets are in current use. They are of the rotary- and stationary-compartment type and of the moving individual-basket type.

Filtration-extraction. --There is a renewed interest in filtration-extraction. This system makes particular efficient use of countercurrent extraction cycle flexibility, final and between-stage drainage, and, in addition, presents the advantage of final solvent content of extracted marc as low as 30 percent, thus providing greatly increased meal desolventizing capacity.

Crisping. --Recent studies on flake preparation have shown that the crisping operation, developed originally in connection with the filtration-extraction process, can be used to great advantage in basket and other types of solvent-extraction. Essentially, "crisping" involves the removal of 1 or 2 percent of water from rolled or cooked flakes by evaporative cooling. This can be done in many ways--on a conveyor belt, by pneumatic conveying, or by passing air through a moving bed of flakes.

Our conclusions at this time are that crisping is about the most important operation ahead of extraction. By proper crisping the mass velocity or flow of solvent or miscella through a bed of flakes can be controlled almost at will, even with bed-wetting solvents. Because thinner flakes may be used, crisping should give the oil mill operator control over solvent and miscella flows, extraction efficiency, and plant capacity not attainable before.

Mineral oil scrubbers. --The use of mineral oil vent scrubbers now makes it possible to reduce solvent losses in hexane-extraction plants to values as low as 0. 1 percent.

Larger screw presses. --The development of larger and more powerful screw presses for cottonseed has been strong competition for improved solvent-extraction installations. However, the use of screw presses in the soybean industry accounts for a relatively small percentage of the total.

Better Products

Mixed solvent extraction. --The pilot-plant development of this process has been completed. Feeding tests with swine and broilers showed that mixed solvent-extracted meals were practically equivalent to soybean meal. Feeding tests with laying hens are under way. Cottonseed flours prepared by mixed solvent extraction were used as the sole source of protein over extended periods in infant feeding and yielded nutritional results practically equivalent to milk protein.

This process and other two-solvent processes are now under investigation for possible use in the developing countries to produce flours for human consumption under the AID program.

Improved solvents. --Much work is under way to provide better hexane solvents, free from minor content of undesirable components and to provide improved extraction results.

Protein quality. --There is an increased awareness of the importance of protein quality of cottonseed meals. Feeding tests are the ultimate criteria used to judge protein quality, but they require much time and are quite expensive. As a consequence, correlations have been sought with chemical tests such as thiamine, free and total gossypol, NaCl solubility, and 0. 02N NaOH solubility. More recently the measurement of EAF Lysine is indicated as a reasonably reliable chemical test by which to gage protein quality. Particular attention has been directed recently to improving this chemical method.

Miscella refining. --In the last few years several new mill-site, miscella refining installations have appeared. Advantages claimed include better control of and higher quality of the oil product, especially color. If these advantages continue to be realized, it is probable that the trend to mill-site miscella refining might accelerate, although it presents a major change in the marketing of the oil product.

Alumina bleaching. --It has been estimated that approximately 25 percent of the annual production of crude cottonseed oil is objectionably high in color. To meet this problem a bleaching process was developed using specially prepared activated alumina, now available commercially from one of the three large aluminum producers cooperating on the project.

Bench-scale and pilot-plant scale tests were highly encouraging, and more recently mill-scale tests have elicited further interest in the process.

Cottonseed cleaning. --Two methods of cleaning cottonseed, based on entirely new approaches, were developed. One of these depends upon the different distances traveled by seed and foreign matter when projected into still air at initial velocities of 5,000 to 8,500 ft. per min. This procedure not only separates foreign matter, but grades the seed on the basis of oil content, protein content, linters content, and free fatty-acid content. Although not being used in the United States, the principle is being used in the Belgian Congo in regular processing operations to improve product quality and in obtaining a higher grade of planting seed.

The other cleaning method depends upon the different rolling and bouncing characteristics of cottonseed and foreign material on an inclined, horizontally moving, textured surface. It is particularly effective in removing foreign material. A pilot-plant model is installed at the Cottonseed Products Research Laboratory, College Station, Tex.

New Products

Confectionery fats. --A process has been developed in which the stearine separated commercially in the solvent winterization of cottonseed oil is hydrogenated under special conditions to control the properties of the product. About 70 percent of the hydrogenated material can be separated by fractional crystallization and has properties more nearly approaching those of cocoa butter than any product previously made. Cocoa butter now sells for nearly 3 times the price received for the stearine as normally produced. There is considerable commercial interest.

Cotton batting. --Progress in developing an improved batting from cotton linters has been discussed by W. G. Van Sann on yesterday's program.

Specific Problems

Mycotoxins. --L. A. Goldblatt discussed the mycotoxin problem yesterday and reported progress in its solution.

Glandless Cottonseed

The introduction of glandless cottonseed will necessitate a restudy of the techniques of cottonseed processing without having to provide for the elimination or inactivation of gossypol by process or equipment design. Processing conditions that are now required for glanded cottonseed may be unimportant for glandless seed, and processing conditions that must be avoided for glanded cottonseed may prove beneficial or profitable for glandless cottonseed.

Acknowledgment

Many persons and groups have contributed to the present highly developed state of the art of cottonseed processing. These developments flow from the efforts and experience of the imaginative and creative minds of those who operate and manage oil mills; who design and build machinery, processing, handling, storage, distributing, and marketing facilities; who develop seed varieties, fertilizers, and insecticides; who develop planting, cultural, harvesting, and garnering practices; and all who deal with cottonseed in any of its forms. These persons are identified with different segments of the industry, with universities, and with organizations such as the National Cottonseed Products Association, the National Cotton Council, the National Confectioners Association, the Quartermaster Food and Container Institute, State Experiment Stations, and various government agencies.

Research Goes On

The thirst for knowledge is insatiable, and as each new item of fact is added to our storehouse of scientific results, those who conceive, develop, design, build, and operate improved processing plants have better facilities to work with, more precise methods for control, more protection against loss, greater safety, more comfortable surroundings, and we hope make adequate profits. The present seems better than the past, and the future promises more than the present. Research goes on. Progress means change.

DISCUSSION

Question: Could you be a little more definite on that air classification system?

E. A. Gastrock: Special equipment was developed to project the seed into still air. We used two methods. One was a series of increasing peripheral velocity spoked reels which would pass the material from one reel to the next, ejecting at the desired velocity, about 6,000 ft. per min. The other method was to project the seed between two moving belts so they would be thrown out at the desired velocity. When we did this by either method, we found that the seed formed a pattern in front of the machine. Most of the foreign matter--the fine material and damaged seed--would be right near the machine, and the sound seed would be at the far end. In addition, we had a gradient of oil content, protein content, and fatty acids so that we could use this for grading the seed. As I pointed out, they are using this to select planting seed in the Belgian Congo. Does that answer your question?

Question: Yes. Is this commercial equipment?

E. A. Gastrock: It is being used commercially now down in the Congo.

ADVANCES IN RESEARCH ON THE USE OF SOYBEAN OIL

by
J. C. Cowan
Northern Utilization Research and Development Division

Abstract

A review of important factors and recent developments in the flavor stability of soybean oil includes: Metallic impurities and their inactivation; linolenate, a source of flavors; lower levels of linolenate and tocopherol and better protection against air and light. Recent work on aldehyde oils and their use is reviewed.

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Research at the Northern Utilization Research and Development Division (NU) has done much to improve the flavor stability of liquid soybean oil--that is liquid oil of edible grade and to extend the nonfood use of the oil. This review will survey our recent work on edible and aldehyde oils derived from soybeans.

Edible Oil

A short review of our work prior to recent developments will familiarize the food chemist and engineer with the edible soybean oil of 20 years ago. At that time, use of soybean oil had increased significantly for shortening, as well as for margarine and other food uses because of the wartime shortage of traditional food fats. As production of soybeans rose, increasingly larger amounts of the oil were used; first for shortening, then for margarine, and more recently as a salad and cooking oil (1, 51). Our and other work showed that additional improvement was possible and that it could be achieved in commercial operations. This growth is summarized in table 1.

Table 1.--Food use of soybean oil

Year	Margarine	Shortening	Other food uses 1/	Total
	Million of pound	Million of pound	Million of pound	Million of pound
1938	40	137	79	256
1943	198	568	207	974
1948	255	708	240	1,203
1953	728	912	510	2,150
1958	1,070	1,055	699	2,824
1963	1,069	1,222	1,353	3,644

1/ Salad Dressings, salad and cooking oils and related use.

Research at NU was initiated just prior to a survey of German industry that revealed a number of procedures reportedly used to improve soybean oil (23). One of these procedures was the use of citric acid during and after deodorization. Our studies confirmed that improvement with citric acid (8) and revealed that the function of citric acid was as an inactivating agent for trace metals (10). Subsequent studies have shown that iron and copper are two of the main culprits and that they influence the oxidation of the oil to give flavors associated with linolenate oils (11).

Amounts as low as 0.1 p.p.m. of iron and 0.01 p.p.m. of copper are sufficient to lower stability (17, 31).

Transesterification and taste-panel studies established that linolenate esters were precursors of undesirable flavors (7). Whereas cottonseed and corn oils usually give rancid flavors after autoxidation, refined, bleached, and deodorized (edible grade) soybean and other linolenate oils, such as rape and mustard seed, give grassy and other flavors at low levels of oxidation--flavors not usually associated with cottonseed, corn, or other oils that contain no linolenate. Subsequent studies showed that the CH_3-CH_2-CH=CH-CH_2-portion of the linolenate molecule gave rise to most of these flavors regardless of whether it was present in linolenate, isolinoleate, linolenate polymers, oxidative polymers, or derived products (24, 30, 53). Hydrogenation stabilizes vegetable oils, but it does not remove all precursors of the undesirable flavors although the rate of appearance of these flavors is much slower and less significant.

Shortenings and margarines made by hydrogenation of oil mixtures high in soybean oil show excellent stability and are generally accepted by the consumer. However, so far as we are aware, hydrogenation alone has not so far given a commercially available liquid oil suitable both as a salad and a cooking oil. Basic studies of glyceride structure show, however, that linolenate is randomly distributed on glycerol (45). Consequently, its removal from the oil by means other than hydrogenation may be too expensive or too difficult. These earlier accomplishments are summarized below:

Information material on	Reference
Citric acid stabilizes soybean oil	(8)
Function of citric acid to inactivate metals	(10)
Trace amounts of metals accelerate off-flavor development	(10)
Iron and copper as low as 0.1 p.p.m. and 0.01 p.p.m.	(17)
Sources of metal contamination	(13)
Structure of metal inactivating agents	(11, 49, 50)
Linolenate and derivatives precursors of off-flavors	(7, 24, 30, 53)
Glyceride structure of soybean oil	(45)
Operation of taste panel for oils	(32, 34)

In 1963, the amount of liquid edible soybean oil used in the United States exceeded the amounts of either of the other two main outlets: shortening and margarine. Five to 10 years ago, liquid edible soybean oil was used in much less quantity. Recent improvements in edible oil based on removal of linolenate, tocopherol, and other factors helped to stabilize this grade of soybean oil and to achieve this increase.

During the past 6 years, a number of our investigations have reconfirmed our previous work on the flavor stability of soybean oil and have extended our knowledge on how to improve the flavor of the edible oil. This research may be divided into 2 main lines of investigations: (1) Methods of improving the stability of soybean oil by protection against autoxidation and (2) methods of improving stability by hydrogenation. Both of these approaches have merit. Only lately have we examined any commercial edible grade of liquid (unhydrogenated) soybean oil that has approached the quality which could be produced in the laboratory. Also, liquid hydrogenated-winterized soybean (HWSB) oils, which are a distinct improvement over most unhydrogenated samples of liquid edible grade, are now available to the consumer. Nationwide distribution of these HWSB oils under manufacturers' and distributors' labels was achieved in 1964.

Although we had contracted for studies on selective hydrogenation earlier (52), our own projects were initiated in 1959. Numerous publications have resulted from this work, including the preparation and evaluation of HWSB oils which I shall review first.

Soybean oil was hydrogenated under selective conditions of 175°C. and 5-lb. pressure of H_2, and winterization carried out for 4.5 days at 40°F. gave HWSB oils with an iodine value (I.V.) of about 110 (12). Yields of 90 percent liquid oil were achieved in pilot studies, and the stability of the oil was improved over the control and substantially improved over the edible grade of unhydrogenated soybean oil commercially available at that time. Examination of commercially available HWSB oils has confirmed our laboratory studies. Table 2 summarizes our results on flavor and oxidative stability of the HWSB oil without citric acid is lower than the unhydrogenated control, presumably because the HWSB oil was exposed to more air and metallic contamination than the control oil during laboratory processing. Citric acid improves the laboratory

Table 2.--Flavor and oxidative stability of hydrogenated winterized soybean oils

Sample	I.V.	Linolenate	Flavor scores		A.O.M.(P.V.)
			Initial	4 days at 60°C.	8 hr. at 98°C.
		Pct.			
Control (with) 1/	127	6.8	7.6	7.0	5.0
Control (without)	127	6.8	8.3	5.9	18.5
Lab. HWSB (with)	111	2.2	7.8	6.8	2.4
Lab. HWSB (without)	111	2.2	6.1	4.5	36
Comm. HWSB (A)	111	2.9	7.3	7.8	2.9
Comm. HWSB (B)	114	2.3	8.3	7.1	2.6

1/ With or without citric acid.

HWSB oil much more than the control. These findings indicate that hydrogenation-winterization provides an improvement in the oil that is actually greater than our figures indicate at first glance. Commercial samples of HWSB oil show considerable stabilization as compared with commercial unhydrogenated oils.

Figure 1 shows that two samples of these commercial HWSB oils were better cooking

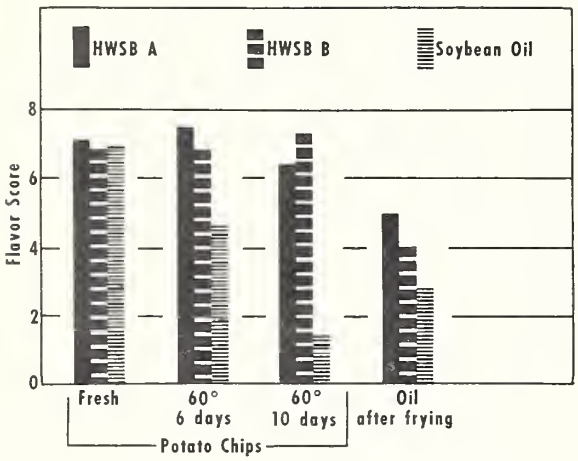


Figure 1.--Advances is research on the use of soybean oil.

oils than an unhydrogenated oil; that is, our taste panel reported that potato chips fried in HWSB oils were more stable and better flavored than potato chips from unhydrogenated oil.[1] These are only preliminary results and further work is being done. Although these oxidative and flavor results show that HWSB oils have definite merit, we believe further improvement is both possible and desirable.

Basic studies on hydrogenation were undertaken with the objective of removing linolenate esters from soybean oil and at the same time retaining not only its liquid nature but its high content of essential fatty acids. The most practical methods of achieving these goals are probably through new procedures for hydrogenation. Although we might hope to hydrogenate the 15, 16 double bond in linolenate (see formula) without hydrogenating linoleate (see formula)--an essential fatty ester, a lesser goal of hydrogenating linolenate without substantial loss in linoleate or without a large increase in trans double bonds appears both desirable and attainable.

$$CH_3CH_2\overset{16}{C}H=\overset{15}{C}HCH_2\overset{13}{C}H=\overset{12}{C}HCH_2\overset{10}{C}H=\overset{9}{C}H(CH_2)_7CO_2R$$

Linolenate

$$CH_3(CH_2)_4CH=CHCH_2CH=CH(CH_2)_7CO_2R$$

Linoleate

Our research shows that nickel catalysts, such as used in our studies to prepare HWSB oil, usually have a selectivity ratio for the rate of hydrogenating linolenate to the rate of hydrogenating linoleate of about 2 to 1 (28, 43). Most other common catalysts give a similar ratio. Much higher ratios of 4 to 5 or more to 1 will be needed to achieve hydrogenations substantially lowering linolenate and forming oils that will pass a cold test for salad use.[2] Several approaches may lead to ultimate success. The use of selective solvents in hydrogenation has given selectivity ratios of about 4 to 5 for linolenate;[3] homogeneous

1/ Moser, Helen A., and others. [Unpublished work.]
2/ Butterfield, R. O., and coworkers. [Unpublished work.]
3/ Sambasivarao, K., and Dutton, H. J. Hydrogenation of Linolenate. XII. Effect of Solvents on Selectivity. [In preparation.]

catalysts have given selectivity ratios 3.5 to 4.5;[4] and unpublished work on heterogeneous catalysts at our laboratory[5] have given ratios as high as 4 or more. It definitely appears that hydrogenation studies may lead to catalysts that can reduce soybean oil to improve its flavor substantially without need for winterization. Recent advances at NU on hydrogenation are summarized below:

Information material on	Reference
Procedure for evaluating catalysts	(4, 5)
Survey of commercial catalysts	(28)
Kinetics of hydrogenation	(48)
Hydrogenation of glycerides and methyl esters	(46)
Reduction with hydrazine	(47)
Parameters of concentrate and temperature	(27)
Labeling with tritium	(6, 29)
Analog computers and kinetics	(2)
Determination of beta-olefinic methyl groups by NMR	(22)
Products formed by Pt and Ni	(44)
Micro vapor-phase hydrogenation	(9)
Homogeneous catalysis	(6/, 21)
Effect of solvents	(7/)
New heterogeneous catalysts	(8/)

The proper inactivation of metals with citric acid or other approved metal-inactivating agent is now standard operating procedure by most companies refining soybean oil for edible use. NU first demonstrated and published on this improvement (8). Without proper care to avoid contamination or to effect inactivation of metals, it is often difficult to repeat experiments in the improvement of soybean oil because traces of metals inadvertently added can easily be the deciding factor in the experiment.

Any exposure of the oil to oxygen that results in reaction probably lowers the flavor and oxidative stability (14). Since oxygen behaves like a difree-radical, almost any exposure to oxygen at room temperature or higher results in some reaction that lowers the stability. However, some exposure can result and the finished products remain edible. There are some limits to this exposure and one study shows that development of peroxide values (P.V.) above 20 measurably lowers flavor and oxidative stability of the oil (14). The extent of reaction with air can be estimated by analysis for oxidative dimer (15, 20).

The air that dissolves in vegetable oils can be a source of off flavors under some conditions. If all the dissolved air in soybean or other oil reacted, it would give a P.V. of about 18. In the presence of traces of copper or iron, flavor quality can be substantially lowered at P.V. as low as 0.5 to 5. Of course, more oxygen than is shown by the P.V. could have reacted since these metals are catalysts for decomposition of hydroperoxides. However, the amount of oxidation equivalent to a P.V. of 18 is enough with many oils to achieve substantial lowering of flavor quality. Thus, nitrogen packaging of soybean oil is a desirable procedure. Light accelerates the development of off-flavors in soybean oils, particularly in the presence of O_2, and protection from light is highly desirable (33). Table 3 summarizes these studies and confirms the desirability of packaging of soybean oil in brown bottles or tin cans.

Table 3.--Effect of light, air, and tocopherol content on the flavor and oxidative stability of soybean oil

Sample	Flavor score (P.V.) Initial	Aged (4 days at 60 °C.) (or light 2 hr.)[1]
Open to air	8.1 (0.7)	3.7 (28)
Nitrogen packed	8.1 (0.7)	7.4 (0.4)
Full (sealed with air	8.1 (0.7)	6.4 (1.2)
Brown glass (light exposed)	8.1 (0.5)	7.9 (0.9)
Clear glass (light exposed	8.1 (0.5)	5.5 (2.2)
Translucent plastic (light exposed)	8.1 (0.5	5.1 (2.6)
Tocopherol content (1500 μg./g.)	8.1	5.8[2]
Tocopherol content (750 μg./g.)	8.1	6.5[2]

1/ References: Moser, Helen A., and others. [Unpublished work.] and (33).

2/ Aged 6 days at 60° C.

4/ Emken, E. A., Frankel, E. N., and Butterfield, R. O. Homogeneous Catalytic Hydrogenation of Unsaturated Fats: Metal Acetylacetonates. [In preparation.]

5/ Koritala, S., and Dutton, H. J. [Unpublished work.]

6/ See footnote 4 above.

7/ See footnote 3 above.

8/ See footnote 5 above.

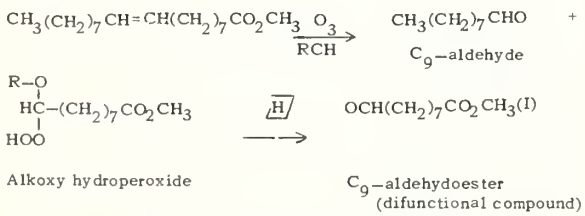
Soybean oil contains high amounts of tocopherols (18). If the tocopherol is lowered to about one-half its original value (1500 μg./g.), stability is improved (19). Lowering of tocopherol can be achieved by deodorization at high temperatures and low pressures and also by mixing soybean oil with other oils much lower in tocopherol. Mixing can also be used to lower linolenate content. When mixing is carried out, it is desirable to inactivate metals in the other oil so that any of its trace metals will not affect the added soybean oil. Other vegetable oils apparently contain metallic complexes that are stable to citric acid and similar complexing agents unless heated (3). NU has made recent advances on unhydrogenated soybean oil, as shown below:

Citations on --	Reference
Protection from air	(14)
Effect of light	(33)
Lowering of tocopherol	(19)
Effect of heat-inactivators	(3)
Analysis for dimers	(15, 20)
Partial hydrogenation-winterization	(12)
Solvent winterization	(10/)
Soybean unsaponifiables	(16, 25, 26)

10/ McConnell, D. G., Evans, C. D., and Cowan, J. C. Solvent Winterization of Partially Hydrogenated Soybean Oils. [In preparation.]

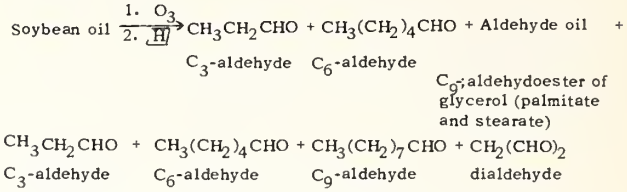
Aldehyde Oils

In addition to our studies on edible soybean oil, we have undertaken considerable research and development on aldehyde oils from soybean oils. When methyl oleate is ozonized in reactive solvents and reduction of the hydroperoxide effected, the C_9 straight-chain aldehyde and the straight-chain C_9 aldehydoester are formed as shown in equation 1 (35).



Equation 1. Reaction of methyl oleate with ozone and alcohol, followed by reduction of hydroperoxide

If soybean oil is used, an aldehyde oil and aldehydes are formed and the reaction is shown in Equation 2 (36).

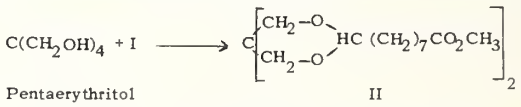


Equation 2. Ozonolysis products from soybean oil

Most oils with unsaturation can be used to make these aldehyde products. Among our contributions have been new solvent combinations for ozonolysis (11/), method of reducing the hydroperoxides (37), and new products from aldehyde oils. Many of these products have potential utility.

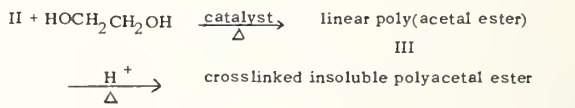
The major product, the C_9-aldehydoester (I) has one unusual property that may be outlined briefly as follows (39):

I reacts with pentaerythritol to give a new type of dibasic ester (II) as shown in Equation 3.



Equation 3. Formation of pentaerythritol acetal of I

II is both an acetal and an ester. It can form linear polyacetal esters (40) by the same alkali catalyzed reaction that is used to form Dacron or Norepol polyesters. These linear polyesters can be crosslinked with an acidic catalyst to give hard insoluble products that have unusual adhesion as shown in Equation 4.



Equation 4. Polyester formation and crosslinking

What commercial use can be made of this and other properties of these aldehyde oils and their derivatives remains to be determined. Other possible developments range from work as diverse as the control of plant

11/ Moore, D. J., Pryde, E. H., and Cowan, J. C. A Comparison of Alcohols as Participating Solvents During Ozonization. Presented at the 55th annual meeting of the American Oil Chemists' Society, New Orleans, April 19–22, 1964.

growth to the formation of new surface coatings.

The C_9-aldehydoester can be converted to a variety of ester acetals that have excellent plasticizing as well as stabilizing functions for polyvinyl chloride (12/).

C_9-aldehyde and its derivatives and the C_9-aldehydoester and its derivatives have plant-growth-regulating activity and large-scale tests are being run to determine if they have sufficient activity under field conditions to merit commercial trials.

The conversion of aldehyde oils to coatings and in polyester products is being studied under A. Rheineck at North Dakota State and under R. W. Lenz at the Fabric Research Laboratories.

At the present time we are searching for superior ways of making these aldehyde oil products, as well as potential new outlets for their commercial use that could lead to commercial production of the aldehydo oil or their simple aldehydoesters. A summary of our advances on aldehyde esters and oil and the references to our work are given below:

Citations on--	Reference
Ozonolysis of methyl oleate	(35)
Ozonolysis of soybean oil	(36)
Reduction of hydroperoxides	(37)
Pentaerythritol acetals	(39)
Poly(ester-acetals)	(40)
Poly(amide-acetals)	(41)
Solvents for ozonolysis	(13/)
Plasticizers for polyvinyl chloride	(14/)
Unsaturated aldehyde oils	(38)
Transacetalization	(44)

Acknowledgment

All this research has, of course, been carried out by many people. Although their names are cited in the references, particular mention should be made of H. J. Dutton, who is now and has been the investigation leader in most of this work and of C. D. Evans, E. N. Frankel, W. K. Rohwedder, C. R. Scholfield, E. H. Pryde, and W. R. Miller, who are individual project leaders.

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13 See footnote 11.

14 See footnote 12.

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DISCUSSION

Question: I would like to ask him what kind of bleaching earth he used to bleach this. I am not talking about the brand, but whether it is an acid-activated gland.

J. C. Cowan: That was a commercial bleaching, other than that we don't know. I would suspect that it was standard clay commercial bleaching. It is true, I think, that other things being equal--and this is hard to achieve--the bleaching step will improve the flavor stability of soybean oil.

CURRENT PRACTICES IN HYDROGENATION OF EDIBLE OILS

by
Porter A. Williams
Hunt Foods and Industries, Inc.

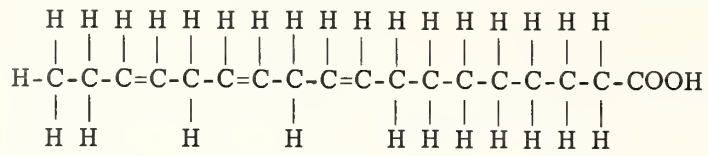
Before considering how edible oils are hydrogenated, it may be of interest to discuss the reason for hydrogenation and how the oils are changed in the process. Reference is made to table 1, which shows the structure of the primary fatty acids present as glycerides in the major edible oils of commerce. You will note linolenic acid has 3 double bonds, and a melting point of 9°F. This is followed by linoleic acid which has 2 double bonds, and a melting point of 20.3°F. Oleic acid has 1 double bond, and a melting point of 61.3°F. Linolenic and linoleic acids are acids which are known as polyunsaturated, and oleic acid is monounsaturated. Stearic acid, melting point 157.3° F., and palmitic acid, melting point 145.2° F., are saturated acids. The only difference in these two acids is the number of carbon atoms--18 for stearic acid, and 16 for palmitic acid.

In the hydrogenation process, 2 hydrogen atoms are introduced into the chain at the double bond. By this procedure, linolenic acid could be converted to linoleic acid. If all the double bonds are closed by introducing 6 hydrogen atoms, then stearic acid would result. The degree of hydrogenation, or the introduction of hydrogen into the fatty acid chains, is used to control the liquidity, melting point, and plasticity of the end product.

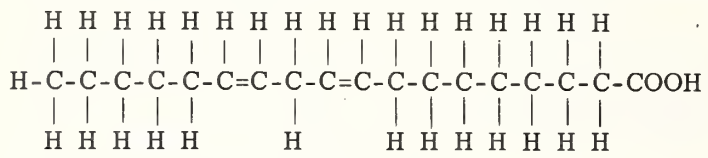
Liquid (nonhydrogenated) fats have a greater tendency to become oxidized and ultimately rancid due to a higher percentage of unsaturated fatty acids that they contain. Since hydrogenation reduces the number of double bonds by the addition of hydrogen at the double bond, it reduces the number of available positions for oxygen to become attached. The result of this is increased stability of the fat.

Table 1

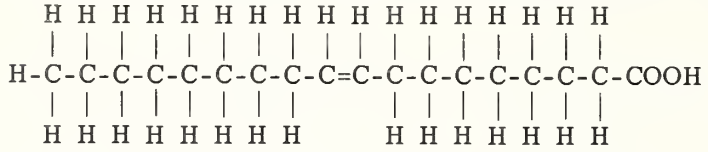
Linolenic acid (18 C atoms, 3 double bonds), melting point: 9.0°F.



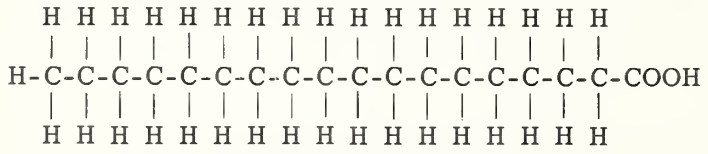
Linoleic acid (18 C atoms, 2 double bonds), melting point: 20.3°F.



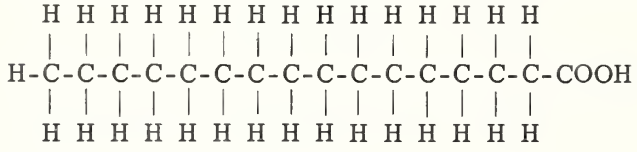
Oleic acid (18 C atoms, 1 double bond), melting point: 61.3°F.



Stearic acid (18 C atoms), melting point: 157.3°F.



Palmitic acid (16 C atoms), melting point: 145.2°F.



Higher stability of hydrogenated products, or resistance to oxidation, is far more important to commercial users than to household users of fats and oils. Reuse of fat for home cooking is not practiced to the extent in the home as it is in restaurants and commercial food production companies. Furthermore, the food is consumed as it is prepared. It is desirable that cookies, frozen foods containing added fats, dry cake mixes, and any other products which require long shelf life unprotected from air be prepared with hydrogenated fats with superior resistance to oxidation.

Liquid shortenings prepared by the winterization of lightly hydrogenated vegetable oils to give a built-in resistance to oxidation are being marketed currently. In addition to being liquid, they are equal, if not superior, in oxidative stability to solid shortenings. They are easier to handle, measure, and lend themselves to complete usage of all the fat in the package.

The utilization of liquid fats in cakes is, and has been, limited to special types. There are a number of liquid cake shortenings containing special emulsifiers being offered to

the commercial consumer. These liquid shortenings normally contain higher percentages of unsaturated fatty acids than do solid commercial shortenings.

The utilization of liquid fats high in unsaturated fatty acids has been increasing due to published medical research, which has shown that one way of controlling serum chloresterol in the blood is by eating fats containing high levels of polyunsaturated fatty acids. If the current investigations confirm previous findings that polyunsaturated fats consumed in the diets of humans will aid in preventing heart attacks, increased usage of oils and special liquid shortenings will result.

The fatty acid composition of the major vegetable oils consumed in the United States is shown in table 2. The marketing of once-refined bleached, and deodorized soybean oil through grocery stores has been limited due to its characteristic flavor reversion problem. The cause of this off-flavor has been attributed to the presence of linolenic acid by most expert oil and fat technologists. The preferential reduction of linolenic to linoleic would be desirable. Many attempts to do this have been made by using various catalysts and hydrogenation techniques, but without too much success on a plant scale. Partial hydrogenation and subsequent winterization of soybean oil are being practiced by some companies in the industry. This has resulted in a product which has reduced tendency to revert. However, the fatty acid distribution has been altered as shown in table 2.

Hydrogenation of oils and formulations of these into margarines has been practiced for many years. Since World War II, considerable improvements have been made in margarine by changes in mouth feel, composition, flavor, and processing. These changes have resulted in tremendous increases in sales. The majority of margarine manufactured and sold in the United States are made from mixtures of cottonseed, soybean, corn, and safflower oils, and may be divided into two general types.

The first type is a mixture of two components with varying degrees of hydrogenation. These components can be formulated from one or more oils--which vary in hardness or degree of hydrogenation, or melting point. The soft fraction, lower melting, and the hard fraction, higher melting, are blended together to obtain a melting point of about body temperature, which makes for sharp mouth melt when eaten as a spread. The second type is made from a hard fraction which has been hydrogenated to such a degree of saturation that when blended with a liquid oil, either cottonseed, corn, safflower, and so forth, gives a margarine which conforms in melting point and other physical characteristics of standard margarine. The latter which contains higher percentages of liquid oil is more polyunsaturated.

There are many factors which affect the end products of hydrogenated fats; and, as a result, each individual company sets up controls which produce fats that meet the requirements of the consumer. These controls are fairly uniform and well known by oil and fat technologists. Differences in equipment catalyst, and so forth, require variations in the process. The main types of hydrogenation equipment used by industry today may be divided into four categories:

Table 2.--Fatty acid distribution in soybean, cottonseed, corn, and hydrogenated winterized soybean oils

Fatty acids	Cottonseed winter oil	Soybean oil	Winterized hydrogenated soybean oil	Corn oil
Myristic	0.7	Trace	Trace	-
Palmitoleic	1.4	-	-	-
Palmitic	22.3	11.7	10.1	11.6
Stearic	1.7	3.3	3.6	1.9
Oleic	17.6	25.2	44.6	28.4
Linoleic	52.6	52.0	36.7	54.0
Linolenic	.0	6.0	1.0	.5
I.V.	111.0	129.0	107.0	126.0

1. Continuous systems using a combination of pressure, mechanical agitation, and hydrogen flow.

2. Batch type involving the use of high hydrogen pressure with no flow, but with relatively efficient mechanical stirring to facilitate good dispersion of hydrogen and catalyst.

3. Batch involving low pressure hydrogen, relatively low hydrogen flow rates, and efficient agitation.

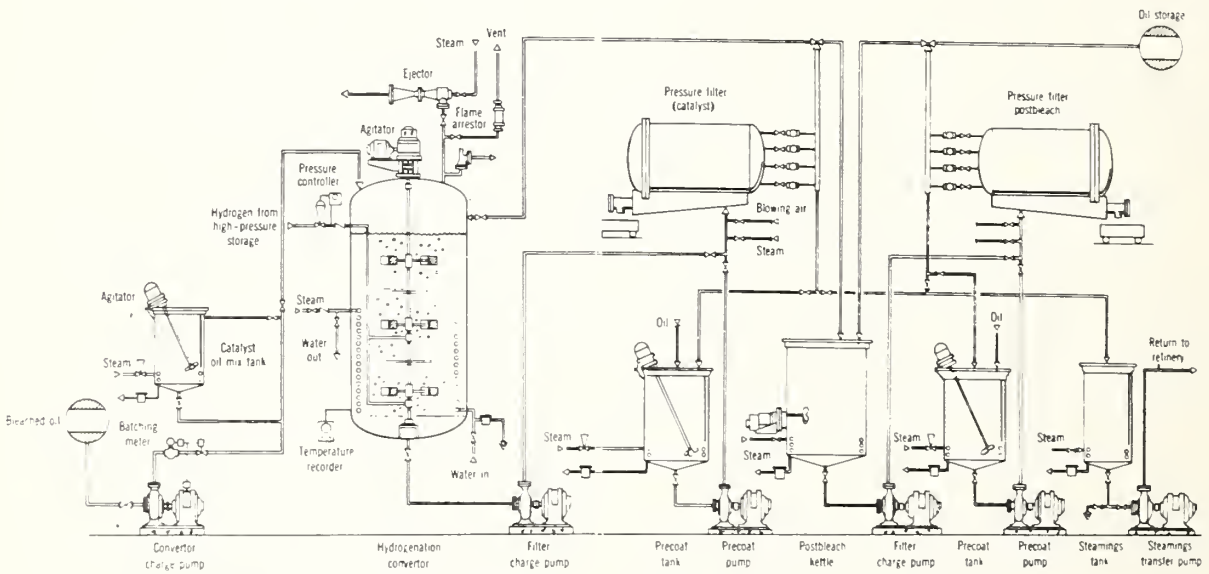
4. Batch using high rates of hydrogen flow, low pressures, and no mechanical agitation.

Even though continuous hydrogenation of edible oil is desirable, and numerous patents and processes have been developed, it is not being used by many oil processors. It certainly is possible to continuously hydrogenate oils, provided the throughput required is large enough to use the system on a minimum number of products of the same type. The multiplicity of products being formulated which require different type catalyst, variable temperatures, and hydrogenation times make it almost impossible to control the physical and chemical composition of these products in a continuous hydrogenation system. The many mechanical problems and developing a satisfactory catalyst to assure uniform quality has posed problems. Any new plant built today would certainly consider utilizing a continuous process.

A batch system with up to 50 lb. hydrogen pressure (figure 1) with no flow, but with very efficient agitation to improve dispersion of the hydrogen is highly acceptable. This is called a dead end system, and lends itself to high volume throughput and good product control. This dead end system requires head space purging to reduce buildup of carbon dioxide, carbon monoxide, and nitrogen.

There is a tendency for development of off odors and flavors in fats hydrogenated in a dead end system. However, a deodorizer with good vacuum and adequate steam treatment will eliminate these problems. It is customary to purge the main hydrogen gas holder during shutdown when the volume of total gas is very low. This keeps the overall loss of hydrogen to a minimum regardless of the type hydrogenation system being used.

Batch systems using low pressure hydrogen and low hydrogen flow rates through the oil with good stirring devices to ensure intimate contact is more extensively used than any other system by industry today. The flow rate controlled by electronic instruments and thermostatic temperature control devices makes for uniform and high quality products. Constant dilution of the return hydrogen gas to the holder with pure hydrogen from the



Hydrogenation plant, dead-end type. (Courtesy of The Votator Division, Chemetron Corp.)

Figure 1. --Batch system

generator keeps the buildup of undesirable gases to a minimum.

Almost all of the industry using standard hydrogenation equipment use wet reduced Ni catalyst. This finely divided nickel is suspended in the oil on diatomaceous earth as a carrier. The hydrogen, introduced into the kettle, becomes attached to the Ni particles; and upon contact with a double bond, as was shown in table 1. The catalyst only serves as an aid in speeding up the reaction, but does not actually enter into the reaction. When the hydrogenation is completed to specification, the nickel with the diatomaceous earth as a filter medium is removed using a closed delivery filter press. The catalyst is then removed from the press, and may be reused for the next batch.

The purity of the hydrogen used is very important in preventing loss of activity and selectivity of the catalyst. There are many processes being used by industry with very satisfactory results. Modern electrolyte steam iron, and steam hydrocarbon plants produce hydrogen which does not normally require any further purification treatment.

DISCUSSION

J. C. Cowan: This has to do with the essentiality of essential fatty acids, and I think a group like this should be aware of a discovery that has been made in Europe in the past 2 years. As a matter of fact, the most important part of it was made about 6 months ago. They have discovered a new hormone that the body synthesizes from essential fatty acids. This hormone can reduce the blood pressure of a human rather significantly. It stimulates smooth muscle. It controls lipid metabolism and is related to fertility. The name of this new hormone is prostaglandin, and I think most of the people who are doing medical research on heart disease and who are aware of this work believe that this is a significant discovery. It might very well take us off this polyunsaturated jag, but prostaglandin is found all over the human body, even in the eyeball, so it is a rather important material.

CURRENT RESEARCH ON HYDROGENATION AND COCOA BUTTERLIKE FATS

by
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Through the years there have been a number of projects on hydrogenation at the Southern Utilization Research and Development Division. The last such project was terminated several months ago. In addition to the projects on hydrogenation, the process of hydrogenation has been and is being investigated in connection with other research. This report will be concerned with work in both areas.

Hydrogenation is the process used to convert a liquid oil into a semisolid or completely solid fat, and of the processes available for the chemical modification of edible oils it is the most important. Several billion pounds of oils are hydrogenated each year in the United States. The cost is well below 1¢/lb. The process is fundamentally simple: Oil and hydrogen are heated to about 300° F. in the presence of a minute amount of finely divided nickel. The amount of hydrogen added is usually less than 1 percent.

While the process of hydrogenation has been in use many years and has been investigated extensively, still better methods of controlling the reaction are desirable. In normal commercial practice even a small amount of hydrogenation produces a large amount of change in the unsaturated portions of the fat which do not hydrogenate (1); that is, the site of the unsaturation is shifted and also there is an extensive transformation into a new type of unsaturation. These changes, referred to chemically as positional and geometrical isomerization, are desirable in making some edible products and undesirable in making others, and the better control of these changes would result in greatly improved fat products.

Hydrogenation tends to convert fatty-acid groups preferentially according to their degree of unsaturation, the more highly unsaturated groups generally, being converted first. This means that in cottonseed oil the linoleic acid

groups are converted mostly into oleic acid groups before the latter are converted into stearic acid groups. The preferential hydrogenation of a given type of fatty acid group in a molecule of fat over the hydrogenation of the same group in a different type of fat molecule is apparently not possible. Obviously, better control of selectivity of the one type and even a small degree of control of the other type would be highly desirable.

The rewards for improving the control of the hydrogenation process are great. With good control it should be possible to make from cottonseed oil a liquid frying oil having an approximately 30-fold increase in resistance to rancidity. Improved margarine oils should be possible. Certain specialty fats, including cocoa butterlike fats, might be possible by direct hydrogenation.

Research Toward Changing the Course of the Hydrogenation Reaction

On the basis of some of our earlier work and that of others, it was suspected that adding solvent to an oil to be hydrogenated might influence markedly the course of the reaction. Using methyl oleate, a derivative of one of the fatty acids of cottonseed oil, a series of experiments was undertaken (2). Some of the results obtained when the oleate was hydrogenated about halfway under conditions which were the same except for the solvent and catalyst employed are recorded in table 1.

Table 1.--Effect of catalyst and solvent on trans-isomer formation during the hydrogenation of methyl oleate to an iodine value of about 50

Catalyst	Solvent	Transbonds [1/]
		Pct.
Nickel	None	76.6
Nickel	Ethanol	35.0
Nickel	n-Butyl ether	29.5
Nickel	Hexane	22.7
Palladium	None	78.3
Palladium	Ethanol	79.1

1/ Calculated or a percentage of the total number of double bonds in the reaction product.

The amount of trans-bonds indicates the change in type of unsaturation (geometrical isomerization) which occurred. The original oleate contained no trans-bonds. Both the nickel and palladium catalysts used in the absence of solvent produced a high degree of transformation. However, when the indicated solvents were used, the amount of change decreased greatly for the nickel catalyst. These changes should be explored further.

In another series of experiments the effect of hydrogenation temperature in changing the site of unsaturation in methyl oleate was investigated (3). The proportion of unsaturation remaining at the original site, the 9-position, decreased as follows:

Hydrogenation temperature, °F.	Percentage of unsaturation remaining at original site
194	74
230	62
338	23
392	17

Because temperature is such an important factor in changing the site of the unsaturation, the use of a solvent in preparing certain products by hydrogenation becomes quite attractive. At a low temperature, the reaction rate is low and the solvent may increase it about six-fold.

Many commercial catalysts for hydrogenation will not function below about 212°F. Investigations were undertaken toward improving the reactivity of nickel catalysts of the Raney type, with the expectation that if a very reactive catalyst could be prepared it might be found useful in the preparation of some specialty products from cottonseed oil. An acid treatment was developed for this catalyst which did, indeed, enhance its activity (4). The improvements attained are reported in table 2.

Table 2.--Effect of acid treatment on the reactivity Raney nickel type catalysts

Commercial alloy	Original catalyst	Treated catalyst
1	9	75
2	48	85
3	11	60

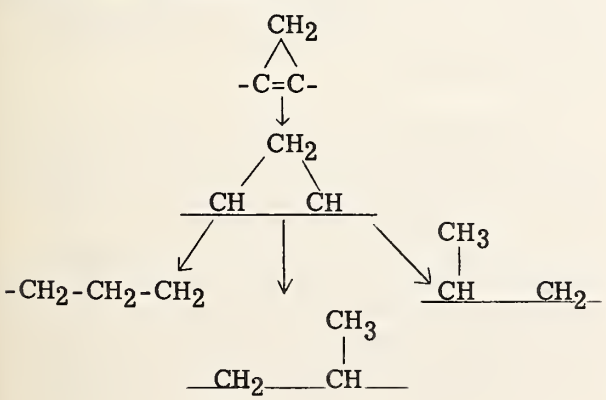
It was mentioned earlier that greatly improved fat products might be prepared if certain fat molecules in a fat product could be hydrogenated while other molecules containing the same fatty acid group remained unattacked. Now a molecule of fat is actually three fatty acid groups tied together by a

molecule of glycerol, and a fatty-acid group in the middle position is known to have some properties somewhat different from those of the same group in the outer positions. When reduced to its simplest form, the desired selectivity in hydrogenation would mean that the reactivity of an unsaturated fatty acid group in a molecule of fat would be affected by its position. To check this possibility, seven hydrogenation experiments employing three different catalysts and several different temperatures were conducted with a triolein product (5). The hydrogenated products were examined using some newly developed analytical techniques. No indication of any selectivity of the type desired could be found.

Hydrogenation of Cyclopropene Acids

Within the last few years, it has been established that cottonseed oil contains about 0.5 percent of unique fatty-acid groups chemically known as cyclopropene acids. They contain the same atoms found in ordinary fatty acid groups except that their arrangement is different. The cyclopropene acids are relatively more reactive than ordinary fatty acids, both chemically and physiologically. Experiments were conducted to establish how rapidly the cyclopropene acid groups in cottonseed oil will hydrogenate. It was found possible to hydrogenate them completely under such mild conditions that only a small proportion of the next most reactive group hydrogenated. It is estimated that the cyclopropene groups hydrogenate about 200 times faster than does the linoleic acid group and about 10,000 times faster than does the oleic acid group.

Others have established that the cyclopropene moiety undergoes hydrogenation in the following manner:



where C represents a carbon atom and H represents a hydrogen atom.

We have found that hydrogenation with the aid of a platinum or palladium catalyst yields several end products, but the proportion of each depends upon the reaction conditions. With commercial nickel catalysts used in the hydrogenation of cottonseed oil, the intermediate or cyclopropane product is produced mostly and very little of the three final products is formed. The intermediate product has been found to be much less reactive than is the linoleic acid group of cottonseed oil, and the intermediate product does not enter into the hydrogenation reaction as long as any sizable proportion of the linoleic acid group is present. Commercial shortening made from cottonseed oil undoubtedly contains cyclopropane acid groups.

Cocoa Butterlike Fats from Fractionated and Hydrogenated Cottonseed Oil

A number of research groups in different parts of the world have attempted to develop processes for making cocoa butterlike fats. The manner in which the confectionery industry uses cocoa butter ensures a built-in shortage, and the United States alone might use as much as 100 million lb./yr. of a really good cocoa butterlike fat, if such a product is developed. Cocoa butter has the unique property of being hard and brittle at room temperature and melting sharply and completely when eaten. These properties are a reflection of its unique structure. The components of cocoa butter are either found in cottonseed oil or might be made from it, provided suitable methods of hydrogenation could be developed. The composition of the two products is given in figure 1. Linoleic acid groups can, of course, be hydrogenated into oleic acid groups and stearic acid groups. Thus, to convert a fat molecule of type (e) into one of type (a), one of the linoleic acid groups of molecule (e) would have to be hydrogenated to an oleic acid group, and the other would have to be hydrogenated to a stearic acid group. However, hydrogenations following current commercial practice would result in many unwanted byproducts. The problem is one of controlling the course of the reaction. Possibly, the preparation of a good cocoa butterlike fat by the direct hydrogenation of an unfractionated cottonseed oil will never be solved.

Fortunately, some relatively recent developments in the cottonseed oil industry and

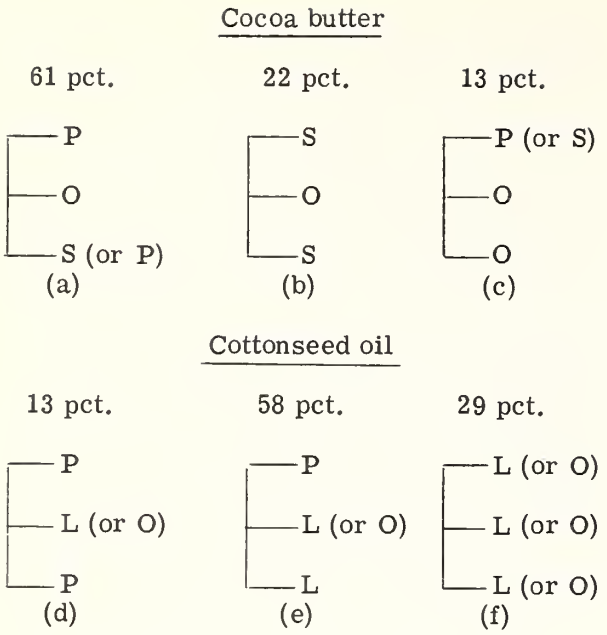


Figure 1.--Approximate percentages of the various types of fat molecules in coca butter and cottonseed oil. Each molecule is composed of three fatty-acid groups and a glycerol group. P represents a palmitic acid group; S, a steric acid group; O, oleic acid group; and L, linoleic acid group.

some developments in our laboratory simplify the problem of preparing a cocoa butterlike fat. Of the almost two billion lb. of crude cottonseed oil produced in the United States each year, over 60 percent is processed into cooking and salad oils, mostly the latter. In making a salad oil, refined and bleached cottonseed oil is cooled slowly and a high-melting fraction, cottonseed oil stearine, is removed. The process is known as winterization. Usually the stearine amounts to about 20 percent of the oil processed. In a few plants winterization now is carried out in a hexane solution. In at least one a centrifuge also is employed, and the stearine is separated so efficiently that it amounts to only about 10 percent of the oil processed. This stearine, which could be produced in very large quantities, is particularly suitable for making cocoa butterlike fats, provided a palmitic acid group is equivalent for practical purposes to a stearic acid group. The two have been found experimentally to be equivalent. The composition of cocoa butter and cottonseed oil stearine from solvent winterization is shown in figure 2 on the basis of fat molecules of saturated, oleic, and linoleic acid groups.

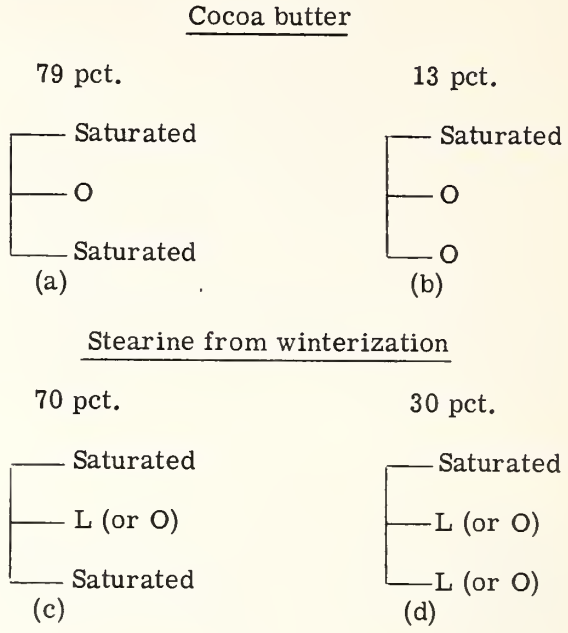


Figure 2.--Approximate percentages of the different types of fat in cocoa butter and cottonseed oil stearine from solvent winterization. "Saturated" represents saturated fatty acid groups (palmitic or stearic); O, oleic acid groups; and L, linoleic acid groups.

In order to obtain a high yield of cocoa butterlike fats from the cottonseed oil stearine a hydrogenation must be conducted which produces the least possible amount of change in the type of unsaturation (geometrical isomerization) and preferentially converts the linoleic acid groups into oleic acid groups and then converts some of the latter to stearic acid groups. A number of such hydrogenations have been attempted using special catalysts, hexane solutions of the stearine, and a low temperature. Data for four of the reaction products obtained are recorded in table 3.

Products HP-4 and HP-5, made with a Raney nickel catalyst, contained a very low proportion of trans-isomers, about one-eighth that which might have been produced by the usual conditions of hydrogenation employed commercially. Obviously, the products would be suitable from the standpoint of isomerization. However, these products also contained a relatively high proportion of both the stearic

Table 3. --Some compositional data on four hydrogenated products obtained from the stearine produced in the solvent winterization of cottonseed oil

Product	Trans-isomers	Stearic acid	Linoleic acid
	Pct.	Pct.	Pct.
Orig. Stearine	0.0	2	36
HP-2	11	8	6
HP-3	11	14	1
HP-4	4	16	17
HP-5	4	21	11

and linoleic acid groups, which was undesirable. In the terminology of the oil chemist, the reactions were nonselective.

Products HP-2 and HP-3, made with a commercial nickel catalyst, contained a significantly greater proportion of trans-isomers, but the proportion was still only about one-third that which might be expected in an ordinary hydrogenation. More important, the content of both the stearic and linoleic acid groups was relatively low.

On analyzing product HP-3 for its various types of fat molecules, the composition was found to resemble that of a typical cocoa butter, except that the content of trisaturated molecules was 21 percent instead of 3 percent (table 4). This difference is not

Table 4. --Compositional data on cocoa butter and a product obtained on hydrogenating stearine from the solvent winterization of cottonseed oil

Type of fat	Product HP-3	Cocoa butter
	Pct.	Pct.
Trisaturated	21	3
Monounsaturated	66	83
Diunsaturated	12	13
Triunsaturated	1	1

serious because the trisaturated components can be reduced readily by a simple fractional crystallization.

Product HP-3 and others similar to it were purified by a fractional crystallization from a hexane solution to obtain a series of cocoa butterlike fats in about a 70 percent yield. A number of physical properties of these fats were determined. The better ones had a short melting range and melted at the desired temperature. Compatability with cocoa butter was excellent. The hardness of the best product was about identical with that of cocoa butter over the temperature range 68 to 91° F. Cooling curves of the fats resembled those of cocoa butter, with the best again being very similar to that of cocoa butter.

The overall process of making cocoa butterlike fats from the stearine produced in the solvent winterization of cottonseed oil appears to be quite attractive from the economic and technical standpoint. In large-scale operations the hexane used to extract the oil from the meal would never have to be removed completely until the final step of fractional crystallization. The process would convert about 70 percent of the stearine, valued at about 12¢/lb., into a product competing with cocoa butter valued at 58¢ to 61¢/lb. Even the approximately 30 percent of high-melting fat product obtained as a by-product would be more valuable than the starting stearine. Since this process was first described, several commercial firms have expressed an interest in it.

The process which has been described is unique in that it yields good cocoa butterlike fats only with cottonseed oil under the conditions mentioned. The process is not applicable to animal fats, soybean oil, or other domestic oils.

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RECENT TRENDS AND DEVELOPMENTS IN SEED STORAGE

by
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The maintenance of seed viability during storage is a major problem encountered in many areas of the world. In the United States, the humid Southern region is frequently a troublesome area for safely storing seed in open warehouse storage for any length or period of time. For seed to maintain high viability and vigor during storage, a suitable storage atmosphere must be maintained. The two major components of the storage atmosphere which influence seed longevity are relative humidity and temperature. Both of these factors influence the seed moisture equilibrium, with relative humidity the most influential. If this moisture equilibrium is too high, seed deterioration is usually rather rapid.

Some realistic examples of the effect of relative humidity on seed longevity are encompassed in some recent research completed at the Seed Technology Laboratory (table 1).

Table 1. --Germination percentages of various crop seed after 11 months' storage at 20°C.

Crop	Init. germ.	Relative humidity 70	75	78
	Pct.	Pct.	Pct.	Pct.
Alfalfa	97.5	93.0	78.0	9.3
Korean Lespedeza	98.8	87.8	57.8	8.8
Fescue	96.0	97.0	90.8	58.0
Orchardgrass	96.2	88.0	80.0	53.5

As indicated by this table, only a small difference of 8 percent relative humidity made a large difference in the viability of these seed after 11 months' storage. The differences in the rate of deterioration at the various levels of humidity can be attributed to different seed moisture equilibriums during storage.

Controlling the Seed Moisture Equilibrium for Safe Storage

Two methods may be used to control the moisture equilibrium seed during storage. One of these methods is to store the seed in a controlled environment. Such an environment is attained by controlling the temperature and relative humidity. For cottonseed, moisture equilibriums at various levels of relative humidity are as shown in table 2.

What is a safe moisture level for the storage of cottonseed? This will vary depending on the temperature during storage. Storage of cottonseed for 6 years at 8 to 10 percent moisture has been found to be nondetrimental on seed germination at temperatures from 1° to 32° C. (1). Simpson (5) has reported that cottonseed with a moisture content of less than 13 percent did not deteriorate in germination after 15 years' storage when stored at 33° F.; when the moisture content was 13 percent, full viability was retained for 13-1/2 years. At 7 percent moisture and a storage temperature of 90° F., cottonseed had a storage limitation of 2 years.

These examples clearly indicate one point concerning seed-storage--that is, the

Table 2. --Equilibrium moisture contents of whole cottonseed, meats, hulls, and oil-free meats at various relative humidities at 25° C.

R. H. (pct.)	Moisture Content (percent wet basis) Whole cottonseed	Meats	Hulls	Meats oil-free
31.0	6.03	5.13	7.67	8.32
43.0	7.23	5.92	9.60	9.33
62.0	9.25	7.73	11.85	12.11
71.2	10.27	8.89	12.62	13.72
81.1	13.21	11.73	15.31	18.29
93.0	22.19	21.40	22.35	32.80

Data by Karon (3)

higher the seed moisture content, the lower the temperature must be for safe storage and vice versa. Some general "Rules of thumb" on seed storage may well be in order at this point. One of these rules states that if you lower the seed moisture content by 1 percent, you will double the life of the seed, or if you lower the storage temperature 10° F., you will also double the life of the seed. Theoretically then, according to this rule, the longevity of seed stored at 10 percent moisture and 60°F. should be 4 times greater than comparable seed stored at 11 percent moisture at 70°F.

The other rule of thumb is that for good safe storage, the numerical value of the temperature in degrees Fahrenheit plus the percent relative humidity should be approximately 100. Under conditions at which this value is obtained, say for example 60 percent R. H. and 40°F. no problem should be experienced in maintaining seed viability over prolonged periods of storage.

Another method of controlling the moisture equilibrium of seed in storage is to dry the seed to a safe storage moisture level and then package in a moisture proof container. Once the seed are inside the container, the seed moisture content should never change, regardless of the environmental conditions which surround this storage container. However, the moisture content at the time of packaging is very important. If this moisture content is too high, seed deterioration will proceed more rapidly than it would have if the seed were stored in some type of porous or open container. A good example of this is indicated in some work by Simpson (4) wherein cottonseed stored at 6 to 8 percent moisture in sealed jars remained high in germination for 7 years, whereas cottonseed stored at 11 percent moisture in sealed jars was worthless after 2 years.

Recently, the effects of various storage containers and seed moisture contents on viability of several types of seed after transoceanic shipment and storage in several foreign countries was studied (2). A few illustrations of the importance of seed moisture content at the time of packaging in moisture proof containers are shown in figures 1, 2, and 3.

In addition, figure 3 also shows the ineffectiveness of cloth bags as seed containers for overseas shipment and storage of seed.

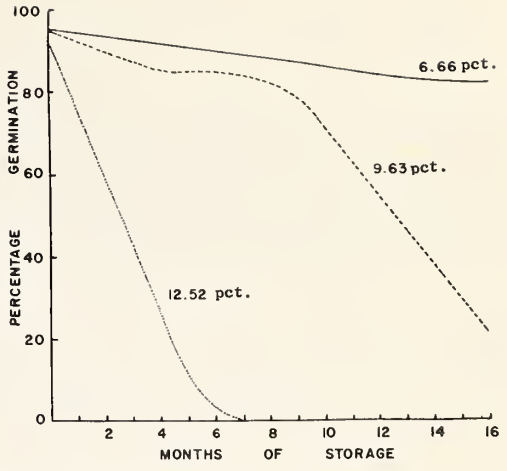

Figure 1.--Viability loss of onion stored in tin cans at various moisture levels.

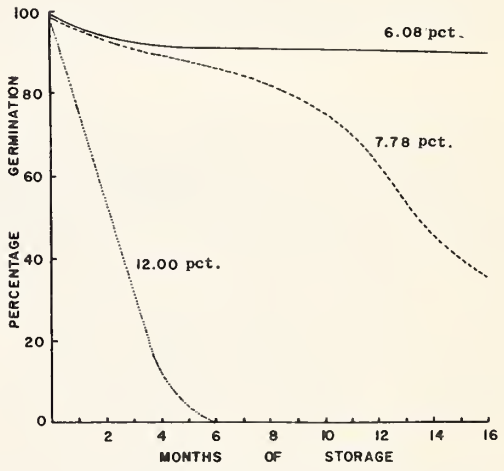

Figure 2.--Viability loss of cauliflower stored in tin cans at various moisture levels.

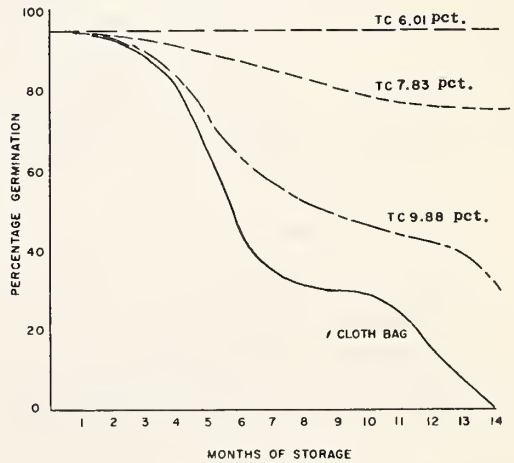

Figure 3.--Viability loss of cabbage stored at various moisture levels.

Seed Vigor

Recently, the trend in the seed industry is to place a greater emphasis on an attribute of seed known as vigor. A simple definition of seed vigor is "the degree of aliveness of seed." Two lots of seed may both germinate 95 percent in the laboratory but when planted in the field, one lot will emerge 80 percent and the other only 30 percent. The seed germination percentage tells you only whether the seed are alive and capable of producing a normal seedling. However, seed vigor is a measure of this "aliveness" and in reality is a more realistic evaluation. How is seed storage linked with seed vigor? Well, first of all good seed storage can only hope to maintain the quality of seed and not improve it. Therefore, to make maximum utilization and realize maximum benefit from your storage facilities, you must start with the highest quality seed possible. What is the use of trying to safely store medium or low vigor seed?

The vigor tests which are available for use today are rather limited. The corn cold test has gained wide acceptance as a measure of seed vigor. The same principle on which the test was developed for corn could also apply for cottonseed. Both corn and cotton are often planted early in the spring under cold, wet field conditions which are not conducive to seed germination and seedling emergence. These are the conditions under which the cold test is conducted.

Another approach to seed vigor which could gain wide popularity in the near future is the rapid aging method of predicting the storability of seed. Such a test would be of great benefit for it would allow one to predict, before he placed seed in storage, how the given seed lot would react after a certain length of storage. Such studies are presently under way at the Laboratory and results are very encouraging.

Mechanical Damage

Another recent trend in cottonseed industry is the awareness of the degree of mechanical damage being inflicted on the seed during the harvesting, ginning, and subsequent processing of the seed. This could produce detrimental effects on the quality of both seed and oil. Recent research has shown that any time the seed coat on cottonseed is broken or ruptured, dead or necrotic tissue can soon be observed in the area where the seed coat was cut or ruptured. Although this may not immediately impair seed germinability, it certainly reduces seed vigor and could eventually render the seed incapable of germinating.

One of the big questions surrounding the aspect of mechanical damage in cottonseed is where the damage is occurring. Recent cooperative research with the USDA Ginning Laboratory at Stoneville, Miss. (6) has revealed that initially approximately 5 percent damage is inflicted on the seed in the mechanical picking operation of cotton. This is an average figure for it has been recently observed that in some instances this figure may approach 10 to 15 percent. Additional damage to the seed may be incurred in the pneumatic conveying and cleaning operation of the seed cotton before it passes over the gin stands. Then, varying degrees of damage occur in the ginning process. Some of the factors which can influence the percentage of cut or damaged seed in the ginning operation are shown in figures 4 and 5. In

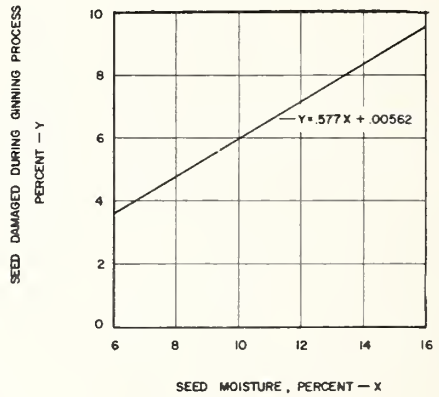

Figure 4.--The effect of seed moisture on seed damaged during the ginning process.

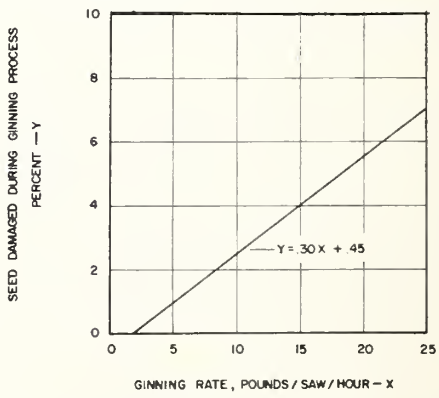

Figure 5.--The effect of ginning rate on seed damaged during the ginning process.

addition, excessive handling of cottonseed also results in a detrimental effect on seed quality (figure 6).

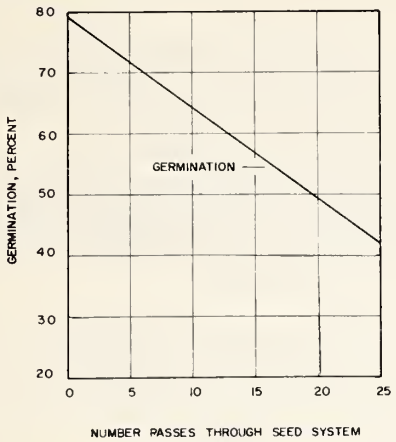

Figure 6.--The effect of excessive handling on cottonseed germination.

What are the overall effects of seed damage to cottonseed? How does seed damage effect the free-fatty-acid content of such seed during storage? Does the addition of a mecurial fungicide or a systemic insecticide to seed, which are damaged, result in lowering seed germination or seedling emergence? It is hoped that future planned research on the problem of damaged cottonseed will enable us to answer these and possibly other questions which many people are asking today.

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DISCUSSION

Question: I am wondering what the effect of storage under anaerobic conditions would have on the germinability of the seed.

J. D. Helmer: As far as the effect of anaerobic storage conditions on cottonseed germination, we have not conducted this specific type of research.

However, I do not want to completely evade the question. An article I reviewed in preparation for this talk involved the storage of cottonseed in various types of gaseous atmospheres--nitrogen, oxygen, and so forth, and the results reported indicated there was no over-all effect.

Question: Have you tried to evaluate the quality of the oil or the meal as related to storage, or do you plan on doing that?

J. D. Helmer: At the present time we are only concerned with seed storage from a planting aspect. We anticipate that we will go into the oil aspect of the problem in relation to damage to cottonseed, but presently from an oil or a meal aspect, we are not conducting any research.

General Chairman Patterson: We will now have the committee report. Lawrence Hodges, chairman of the Resolutions Committee. (Mr. Hodges presented the following Resolutions Committee Report.)

RESOLUTIONS

BE IT RESOLVED, That we express our appreciation and thanks to the program committee and all who have devoted time and effort to the preparation of the excellent program presented at this, the FOURTEENTH COTTONSEED PROCESSING CLINIC. We also express our thanks to those appearing on the program.

BE IT RESOLVED, That we desire to express to Dr. C. H. Fisher, Director, Dr. Bruno H. Wojcik, Assistant Director, and the staff of the Southern Regional Research Laboratory our sincere thanks for the hospitable and kindly manner in which we have been accommodated during our visit here and the further desire that this most pleasant association may be continued.

BE IT RESOLVED, That the work on mycotoxin, as presented by Dr. L. A. Goldblatt, be continued.

BE IT RESOLVED, That we acknowledge, with appreciation, the program of the Labora-

tory toward regaining the market for cotton linters through their efforts in the development of the cotton linter batting.

BE IT RESOLVED, That we express deep appreciation to the USDA for not having moved nor reduced any phase of the New Orleans Laboratory's work with respect to cottonseed and related products, from the area of production.

BE IT RESOLVED, That the value of the Cottonseed Processing Clinic has been established as evidenced by the widespread interest and attendance. THEREFORE, BE IT FURTHER RESOLVED, That these meetings be continued as a benefit to the economy of the cotton growing industry.

Signed:

Lawrence Hodges, Chairman

Norman Bartmess

Robert Patterson

L. W. Hodges: This is signed by the Resolutions Committee. I make a motion that these resolutions be adopted.

W. K. Martak: Second the motion.

General Chairman Patterson: Any objection? Adopted. I want to call on Dr. Fisher, if he will make a few remarks.

C. H. Fisher: Thank you for this privilege. I think this has been a most successful meeting, and I have heard many compliments about it.

We appreciate the complimentary remarks about the work of the Southern Division in the resolutions. I wish to thank all participants, the audience, the speakers, the chairman and the chairmen of the various sessions, the Program Committee, the officers of the Mississippi Valley Oilseed Processors Association and especially Mr. Martak, the president, and Mr. Garner who helped put the program together.

While expressing gratitude, I'd like to add that we are very grateful to this Association for the privilege that we have had of working with you over the years.

We have enjoyed this relationship for some time, and we appreciate it. It means a great deal to us personally and professionally.

While talking about these meetings, I thank Mr. Gastrock for his talk and for the important role he had in the original organization of this annual conference.

It isn't easy for someone to come in at the last minute to present a paper, but Mr. Bill Davis did just that. He gave an excellent talk and we are grateful.

I wish to thank Vernon Bourdette and his staff and, of course, Dr. Wojcik, Mr. Mazzeno, Mrs. Sharar and other staff members for their contributions.

Although the meeting this year has been unusually successful, we are always eager to make the meetings better and to give them the character preferred by members of the Association. If you have suggestions of any kind, for example, topics that you would like to have emphasized, we shall be glad to hear from you any time during the coming year. This is your Clinic, and we want it to serve your needs. We have talked with Mr. Martak and Mr. Garner, and it has been agreed that the dates of February 7 and 8, 1966, will be the date of the next clinic.

We have not scheduled a formal tour of the Laboratory, but we hope that all of you will visit the Laboratory while in New Orleans. We are looking forward to seeing you next February.

General Chairman Patterson: Thank you very much, Dr. Fisher, for those kind remarks. I would like to ask Bill Martak to come and say a few words, if he will.

W. K. Martak: Thank you, Bob. We again thank Dr. Fisher and his entire staff for an excellent conference. We also owe a vote of thanks to our secretary, Clarence Garner, for his tireless efforts and wisdom in helping plan this Clinic. We thank our conference coordinator, Mrs. Sharar, for a job well done, as well as the ladies at the desk. We thank all of our industry friends for attending and those who appeared on the program. It was kind of them to put us on their busy schedule, for we know a number of them traveled a great distance.

I have heard a number of comments that this conference is one of the best, if not the best. This was not by accident; we had very experienced men guiding us. Therefore, we thank our general chairman, Robert Patterson and cochairmen, Dr. Wojcik, and Laurence Mazzeno and their committee for preparing and presenting this excellent program.

General Chairman Patterson: We are going to have another good meeting in April, and that is the annual convention of the Mississippi Valley Oilseed Processors Association, in Biloxi. We hope that as many of you as can will come. We'd like to see you over there.

We have one alumnus here with us today, and we appreciate his interest in this group. That is Mr. E. L. Patton, Mr. Patton used to be with the Laboratory and we certainly appreciate his making the effort to come to this Clinic.

If there are no other announcements, we stand adjourned, and good-bye.

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